POWER

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THE engineer who takes charge of a power plant such as is found in many of the large office buildings, must possess some of the qualifications of a business man, in addition to those of a first-class mechanic.

The successful engineer usually has spent his younger days in machine-shop or millwright work, in addition to an apprenticeship as fireman or oiler, and has later supplemented this with more or less technical study. By the time he has gone through the various stages he has probably spent at least ten years of hard work and at last finds himself in charge of a plant.

Here he is confronted with problems of a different nature and begins to realize that the cost of operating the plant and the results obtained for every dollar spent is the standard from which the owner judges his worth and ability.

One man may take charge of a plant which is in good condition and run it until it cannot be run any longer except at a great loss; another will take charge of the same plant, run it, and maintain it in first-class condition regardless of expense; but the *real* engineer will maintain and keep everything in first-class condition at a minimum cost. This requires business ability as well as mechanical skill.

Careless handling of supplies and slipshod methods often incur a useless expense equal to the chief's salary.

Ask yourself the following questions and the answers will indicate to which type of engineer you belong:

Do you know how much waste should be used in your plant every day, and how much is thrown aside through indifference on the part of the men?

How much packing is spoiled by lying around the engine room, or do you give out just enough and keep the rest locked up?

How much oil at 30 cents a gallon does your oiler waste every day?

As chief engineer, do you know from personal observation that your boilers are clean or do you take the fireman's word for it?

How many traps are blowing steam and how much water is being lost through improperly packed pump rods? Or, what percentage of the water handled is lost through leaky suction and discharge valves?

Is the slide valve of your engine tight? When did you examine it last and in what condition did you find it?

Have you any idea as to how much steam per horsepower-hour your engine should take; and having that knowledge what means did you take to ascertain if the engine was exceeding this amount?

Are your grates in good condition or are they full of holes and waste coal?

Do not poor grates, poor fire tools and an indifferent chief soon make the best of firemen lose interest in their work?

Another prolific source of waste that few engineers take into consideration is what might be termed "tinker jobs." These often take up more time and material than the article mended is worth. As an instance of this, not long ago, an oiler was found industriously trying to solder the bottom of an old squirt can which, when new, cost about 25 cents. The soldering irons were heated by a gas furnace which had been burning for more than 30 minutes. The cost of this gas added to that of the solder and the man's time amounted to more than the price of a new can.

Although the operating force should be able to make all ordinary repairs in a medium-sized plant, the line should be drawn between repairs and tinker work.

Here is where the business part of the chief's work comes in. He should supervise, criticise and exert constant vigilance; that is the price of success.

The Cincinnati Water Works

By A. D. Blake

Turbid water is taken from the Ohio river and after passing through a filtration plant is delivered to consumers over 99 per cent. pure. The total capacity of the system is 120,000,000 gallons per day, two large pumping stations being employed, one to pump from the river to the filtration plant, the other to distribute to the various sections of the city.

To one familiar with the turbid and muddy waters of the Ohio river in the vicinity of Cincinnati, it will appear somewhat startling that the 360,000 inhabitants of this city are supplied from this source. Moreover, the supply is not taken from the headwaters of the river but from a point about nine miles above the city and in the path of continuous navigation. Yet by the time the water reaches the consumer it is 99.2 per cent. pure, as shown by chemical analysis.

To purify this water and distribute it throughout the city has necessitated the construction of an elaborate waterworks system involving an expenditure of nearly $11,000,000. This system, although not the largest, is in many respects one of the most complete in existence.

Reference to Fig. 1 will give an idea of the general layout of the system. The intake is on the Kentucky side of the river, opposite the village of California, as there is a greater depth of water on this side, there being at least 20 feet at the intake pier even during periods of low water.

A tract of land on the Kentucky shore was first purchased from the city of Covington for $3500; but after the purchase certain officials of Campbell county, Ky., interfered with the construction of the intake pier and tunnel, claiming that the bed of the river to the low-water mark on the Ohio shore belonged to the State of Kentucky. Ten acres of river bed were thereupon purchased from the latter State for the sum of $2500, and other property on the Kentucky side was purchased from private individuals for $18,750 in order that the city of Cincinnati might control that section of the river bank and give it proper sanitary protection.

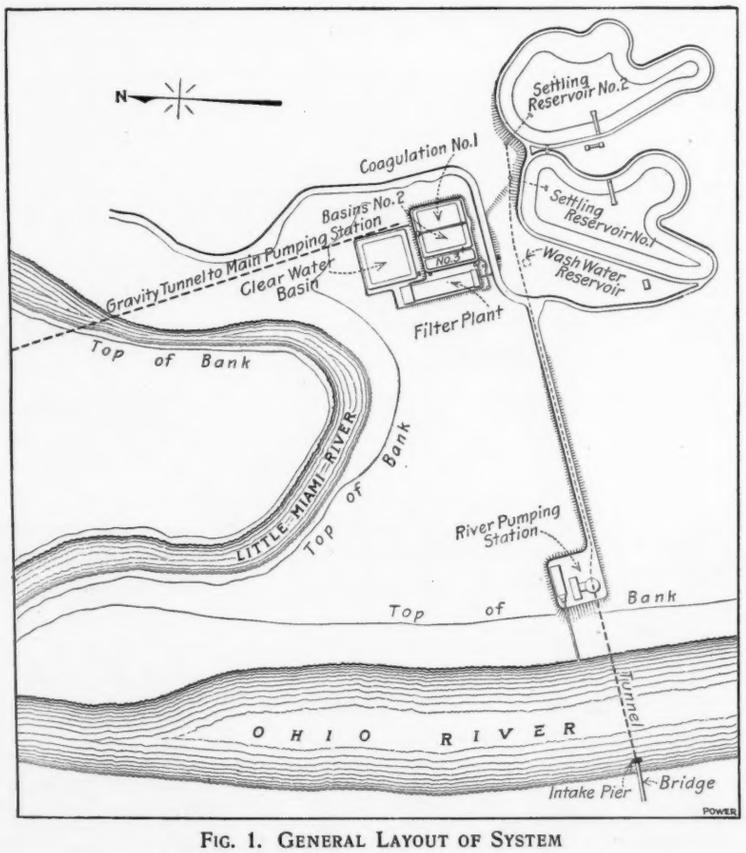


FIG. 1. GENERAL LAYOUT OF SYSTEM

Therefore, although the Cincinnati water department does not have to pay any annual rental to the State of Kentucky, it does have to pay State, county and township taxes upon the assessed valuation of this property.

From the intake pier containing a shaft well, a screen well, hydraulically operated sluice gates, etc., the water is carried a distance of nearly 1500-feet in a 7-foot brick-lined tunnel 50 feet below the river bed to the Ohio shore. Here the tunnel terminates in a vertical shaft which extends up through the center of the circular engine room of the river pumping station.

River Pumping Station

Placed radially around this shaft and taking their suction from it, are four 30,000,000-gallon vertical, triple-expansion pumping engines, having 29-, 54- and 82-inch steam cylinders, 37½-inch water plungers and a common stroke of 96 inches. These were built by the Camden Iron Works and are of the self-contained type, each engine having an exhaust heater, surface condenser and air pump attached. On six-day duty trials two of the engines showed the following results:

Duty per 1000 pounds of steam at 150 pounds and 90 degrees superheat, 193,500,000 foot-pounds.

Duty per 1000 pounds of saturated steam at 150 pounds, 172,000,000 foot-pounds.

An idea of their size may be gained from the fact that they have an extreme hight of 106 feet above the pump-pit deck and weigh 1500 tons each, the foundations being carried on timber caissons. An electric elevator is used by the attendants to reach the various galleries around the engines. Above the engines is a 30-ton traveling crane, one end resting on an extension of the central shaft, the other on a circular track carried by the engine-room walls.

Owing to the relative location and the hight of the engines it is impossible to obtain a view of them as a whole; Fig. 2, however, shows the cylinders and the upper part of the central shaft.

Electrical energy for operating the crane, elevator, lights, valves, etc., is furnished by three 150-kilowatt De Laval turbo-generator sets.

Steam is supplied at 150 pounds pressure and 500 degrees by eight 210-horsepower Stirling boilers equipped with American stokers and Green economizers. Adjoining the pumping station is a steel coal-storage bin of about 7000 tons capacity. Coal is brought down the river in barges and unloaded onto an inclined cableway by which it is conveyed in cars to the storage bin. From the bin it is

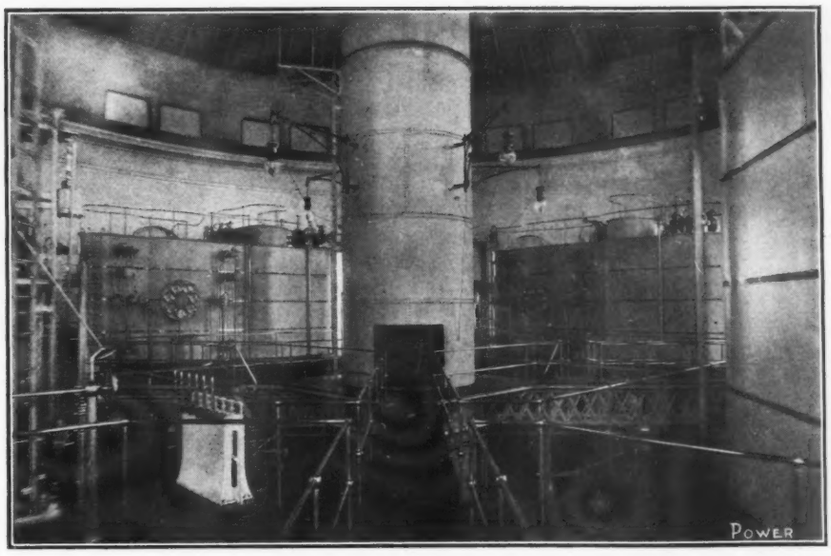


FIG. 2. ENGINE ROOM, RIVER PUMPING STATION

The construction of these basins is worthy of note. After being excavated and tamped they were lined with concrete which was covered by a thick layer of waterproofing, and upon this was laid a specially prepared hard-burned brick. These were laid in herringbone order with considerable space between each brick, and these spaces were then poured with grout. Such a lining was necessary to withstand the high water pressure from the nozzles when washing the basins.

The water is drawn at the surface from these basins and is conveyed to the filter house. Here it passes through sand filters and then flows to the clear-water reservoir. The filters consist of a bed of gravel upon which rests a 2-foot layer of sand, the sand being kept separate from the gravel by a fine-meshed copper-wire screen.

There are 28 filters in all, each hav-

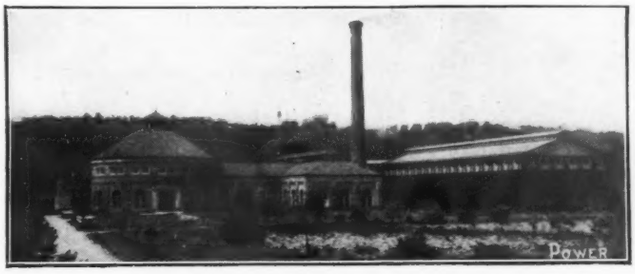


FIG. 3. RIVER PUMPING STATION

FIG. 4. FILTER HOUSE

discharged into dump cars which are run on a narrow-gage track to the fronts of the boilers and the coal is unloaded by hand. The one surprising feature is that such a cumbersome and expensive system of coal handling should have been employed in a plant otherwise uptodate in every respect.

Fig. 3 is an exterior view of the river pumping station, showing also the coal-storage bin. The building is of Bedford stone with a red-tile roof and presents an attractive appearance.

FILTRATION PLANT

From the river station the water is pumped through two 60-inch mains, against a head of 140 feet, to two settling reservoirs having a combined storage capacity of 330,000,000 gallons. These reservoirs serve a twofold purpose, that of providing ample storage capacity and a means by which much of the mud is allowed to precipitate before the water passes to the filter plant. The water remains in these reservoirs from two to four days and is drawn off at the top through four floating pipes. From here it is conveyed to the head house where it is metered and is treated with sulphate of iron and lime water. It then flows to the coagulation basins, shown in Fig. 5, where it remains for several hours, allowing sedimentation to take place.

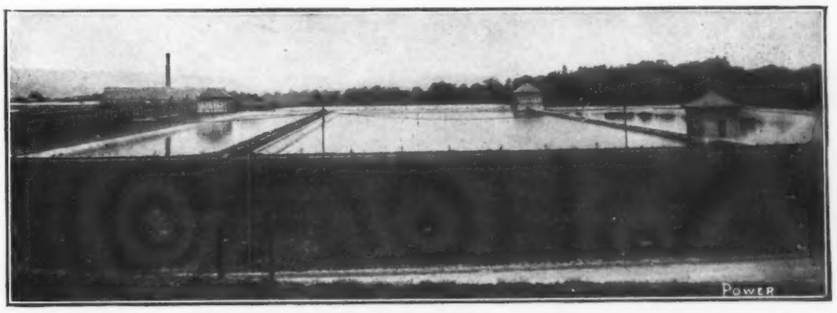


FIG. 5. COAGULATION BASINS

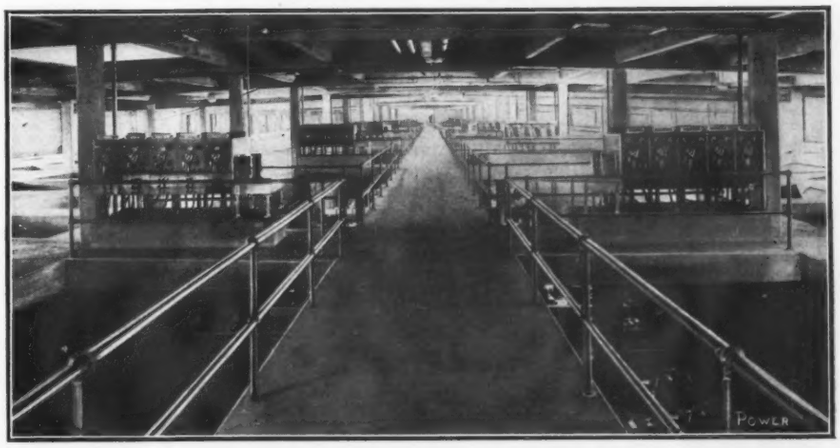


FIG. 6. FILTER BASINS AND CONTROL BOARDS

ing a capacity of 4,000,000 gallons per 24 hours. When in use a filter is washed about every 18 to 20 hours. This is accomplished by forcing filtered water up through the bed of gravel and sand and allowing the overflow to discharge into the river. The operation requires about 5 minutes and it is estimated that the water required for washing forms about 3 per cent. of the total water filtered. All the valves are electrically operated and each filter is equipped with a switchboard containing the various motor switches and the indicating lamps showing when a valve is open or closed. These are shown in Fig. 6.

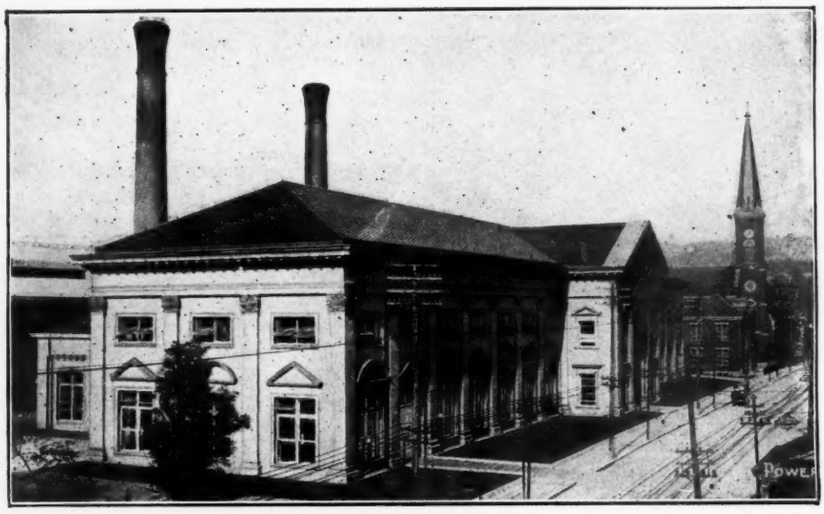


FIG. 7. MAIN PUMPING STATION

after being filtered. An exterior view of the building is shown in Fig. 4.

From the clear-water reservoir the water flows a distance of 4½ miles through a brick-lined gravity tunnel (drilled through solid rock) to the main pumping station located on the outskirts of the city.

MAIN PUMPING STATION

This station supplies two systems: one a high-pressure system at 195 to 210 pounds to the hill sections of the city and the Mt. Auburn tanks, the other a low-pressure system at 75 to 85 pounds supplying the lower parts of the city, the Western Hills pumping station (an auxiliary station of 2,000,000 gallons capacity) and the Eden Park reservoir.

The low-pressure service is served by three 25,000,000-gallon vertical triple-expansion engines built by the Holly Manufacturing Company. The steam cylinders are 32-, 60- and 90-inch and the water plungers 38¼ inches in diameter, with a common stroke of 60 inches. Three pumping engines of similar design but of 12,000,000 gallons capacity serve the high-pressure system. These engines are of the self-contained type having exhaust heaters, surface condensers and air pumps attached. A view of them is shown in Fig. 8, the engines and piping being painted white with the engine-room walls of white enameled brick.

Steam is supplied at 160 pounds by twelve 210- to 225-horsepower Geary boilers and four 300-horsepower Aultman & Taylor boilers. The former are equipped with American stokers and the latter with Murphy stokers. Recently, however, Gwynn burners for natural gas have been installed under the Geary boilers and coal is now used only for standby purposes. Four Green economizers are installed and the natural draft is assisted by two Buffalo Forge Company's blowers.

The boilers are set out in the room so as to afford ample space on all sides and the settings are of buff brick. This, together with the abundance of light from overhead skylights and the absence of coal dust, gives the boiler room a very pleasing appearance.

Back of the boiler house there is a coal-storage bin similar in size and design to the one at the river pumping station. This is kept filled for use in case the gas supply should give out.

A general view of the boiler room is shown in Fig. 9.

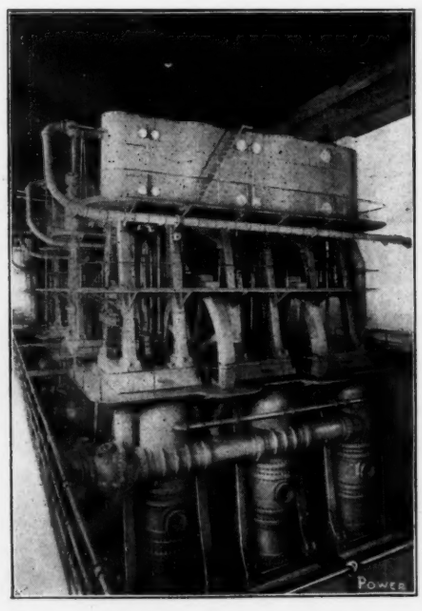


FIG. 8. ENGINES IN MAIN PUMPING STATION

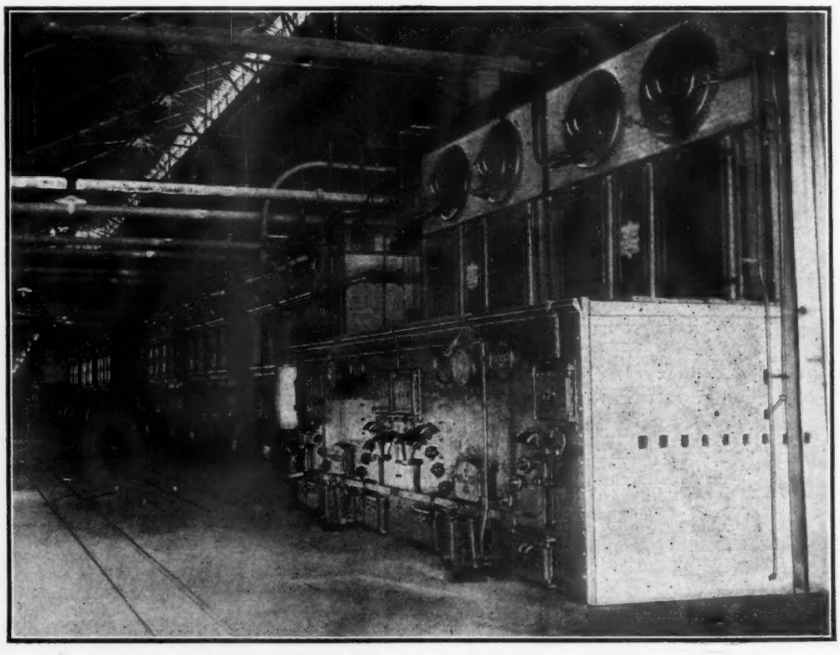


FIG. 9. BOILER ROOM IN MAIN PUMPING STATION

A well equipped chemical laboratory forms part of the plant and a corps of chemists is kept busy continually making analyses of the water both before and

Operation

The natural gas burned under the boilers at the main pumping station costs 11 cents per thousand cubic feet and contains an average of 1060 B.t.u. per cubic foot. The coal formerly used contained 13,400 B.t.u. per pound and cost $1.87 per ton. Hence, 12.64 cubic feet of gas are equivalent in heat value to 1 pound of coal and cost 48 cents less. Another saving resulting from the substitution of gas for coal has been a large reduction in the boiler-room force.

The cost of operation for the entire system has shown a steady decrease during the three years it has been in service; from a total cost of $16.09 per million gallons in 1908 it was reduced to $14.36 in 1910; and from present indications the report for 1911 will probably show still better results.

A very complete system of cost keeping has been introduced by the superintendent, S. G. Pollard, and it is now possible to tell at any time just how much it is costing to operate any branch of the system.

The average duty at the main pumping station during the past six months, reduced to an equivalent per hundred pounds of coal, has been 137,800,000 foot-pounds.

For the past year the average daily consumption of water has been over 46,000,000 gallons. With a total rated capacity of 120,000,000 gallons per day, it will be seen that the water supply for the city is ample for years to come.

The Cincinnati water department is entirely self-supporting and the benefits of the new water-supply system are apparent from the fact that the typhoid-fever rate has been reduced from 19 to 5.7 persons per 100,000 of population since its installation.

Kinks at Pendleton Generating Station

By A. De Groot

Among the interesting features of the Pendleton station of the Cincinnati Traction Company is an arrangement whereby strainers on the circulating-water intake are dispensed with and the direction of flow through the condensers is reversed at will. Another novel kink is an auxiliary air valve on the dry-air pump which assists the circulating-pump suction.

The Pendleton generating station of the Cincinnati Traction Company is one of the older plants of this company and of the system of which it is a part. Plans have been drawn for enlarging and entirely remodeling this plant so as to conform to the present standard of electric-traction practice; that is, generating alternating current at high voltage for transmission to substations where it is stepped down and converted to direct current for distribution by the trolley feeders.

As it has been necessary to keep the plant in operation, the reconstruction has necessarily progressed slowly. Consequently the station now contains an assorted equipment ranging from modern turbo-generators to old-time belt-driven machines, some of a type ancient enough to be almost a curiosity. In spite of their obsoleteness, however, some of these machines still show good economy.

The present equipment consists of fourteen 525-horsepower Babcock & Wilcox boilers, two 6000-kilowatt, three-phase, 25-cycle, 6600-volt Westinghouse turbo-generators, constituting the new part of the plant, and two 300-, one 1200-, one 1300- and one 1500-kilowatt, direct-current engine-driven units; these together with a 1500-kilowatt turbine constitute the old equipment. Another 6000-kilowatt turbo-generator is about to be installed and the plans call for ultimately adding an additional capacity of 30,000 kilowatts.

Although this assorted equipment is of more or less passing interest, the features which impress the visitor most are several ingenious kinks which have been employed to overcome obstacles in operating conditions.

Reversing Valve

Perhaps the most novel of these is the reversing valve used in connection with the circulating water for the surface condensers. This water is taken from the Ohio river, a few hundred feet to the rear of the plant, and formerly much trouble was experienced by drift matter obstructing the strainers on the intake pipes. Owing to the very high rise and fall of the Ohio river at different seasons of the year, it was necessary to have the intake close to the river bed in order that it might be submerged at periods of low water. Hence, the extreme submergence of the intake pipes at high water made the strainers inaccessible for cleaning or removing obstructions.

Accordingly, it was decided to dispense with the strainers entirely and to substitute a reversing valve, whereby the direction of flow might be reversed at will; that is, the intake and the discharge pipes are made interchangeable.

The device is shown in Figs. 1 and 2 and consists of a cylindrical chamber into which lead six pipes as indicated. The interior is divided into three compartments by a diaphragm and two pistons, these being controlled by a hydraulically operated piston placed at one end

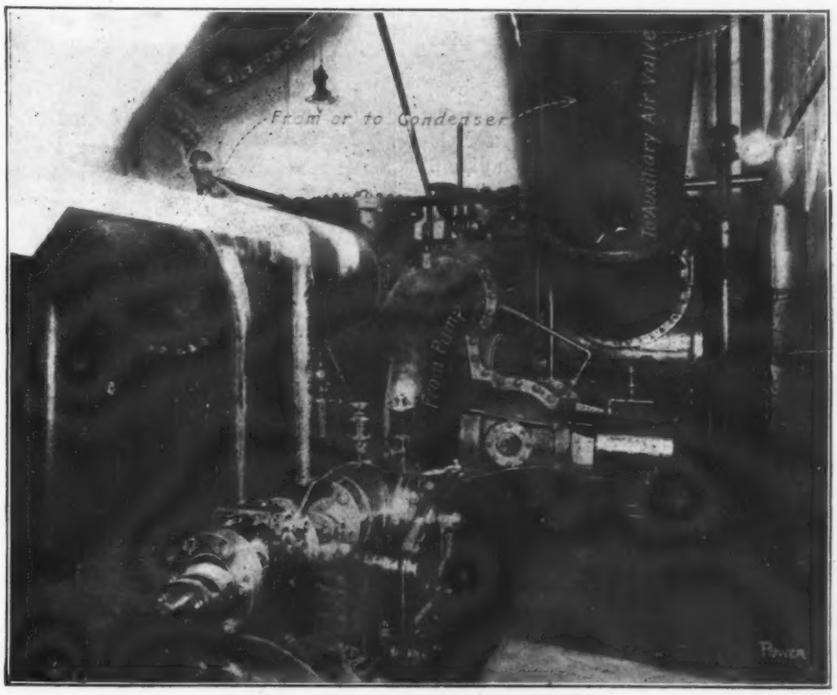


Fig. 1. Reversing Valve and Circulating Pump

of the casing. When the diaphragm and pistons are in the position indicated by the solid lines the direction of flow is from pipe 6 through pipe 5 to the pump; returning from the pump through pipe 2 and passing to the condenser through pipe 3; the discharge from the condenser is through pipe 1 to the valve chamber, thence through pipe 4 to the river. By simply throwing a lever the diaphragm and pistons are moved hydraulically to the position shown by the dotted lines. The direction of flow is now reversed, as indicated in parentheses; that is, the intake is through pipe 4, the water passing to the pump through pipe 5, from the pump through pipe 2, and to the condenser through pipe 1; the discharge from the condenser is through pipe 3 and thence through pipe 6 to the river. By this arrangement the intake is freed of driftwood and other obstructions without interfering with the operation of the condensers. Moreover, it furnishes a means of keeping the condenser tubes entirely free with a minimum amount of labor.

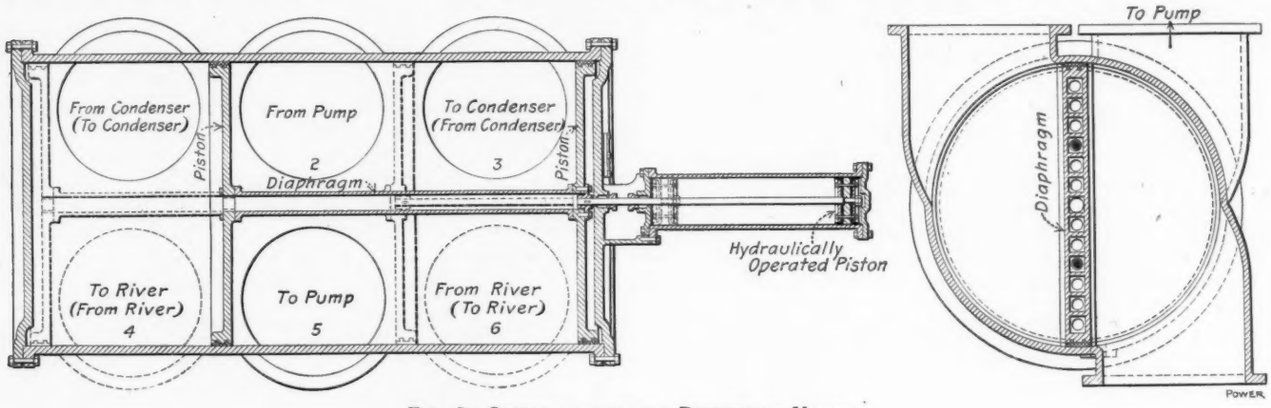


FIG. 2. SECTION THROUGH REVERSING VALVE

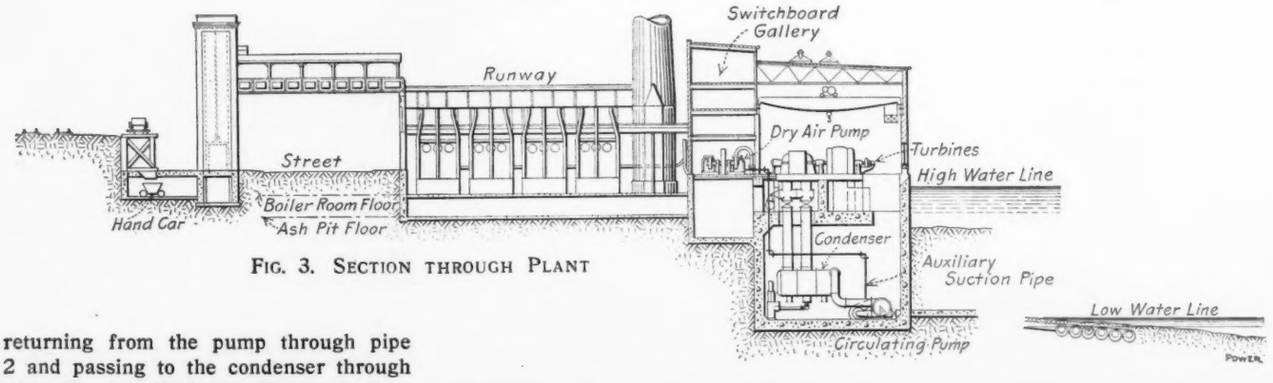


FIG. 3. SECTION THROUGH PLANT

AUXILIARY AIR VALVE

Another ingenious device is that employed to maintain the suction lift on the circulating pumps during periods of low water. At such times there is a suction lift of about 20 feet on the centrifugal pumps which ordinarily they would have difficulty in maintaining.

The dry-air pumps, which are of the Laidlaw-Dunn-Gordon type, are located in the turbine room (see Fig. 3) and to these are fitted auxiliary air valves connecting with the suction chambers on the circulating pumps. When the piston of the dry-air pump has completed its stroke, leaving behind it a partial vacuum, the auxiliary air valve opens and throws this vacuum onto the suction of the circulating pump. This assists the suction of the latter pump and the closing of the main air valves on the dry-air pump prevents the vacuum on the condenser from being disturbed. By this means the suction of the circulating pump is aided without throwing any additional load on the dry-air pump. A view of the auxiliary air valve on one of the pumps is shown in Fig. 4. Of course, this device is used only at periods of low water, the river furnishing sufficient head at other times to overcome the suction lift.

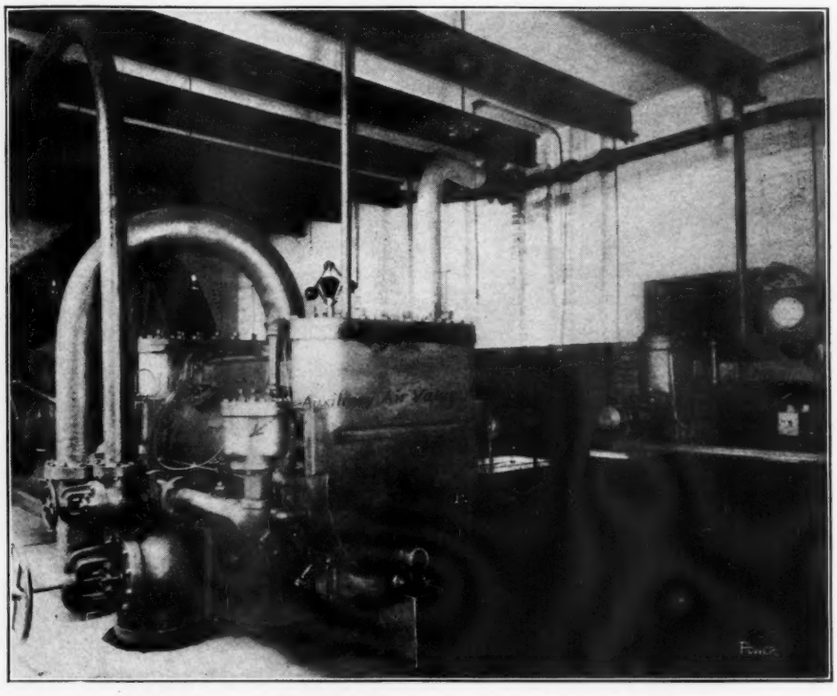


FIG. 4. DRY-AIR PUMP SHOWING AUXILIARY AIR VALVE

Coal-handling System

The method of handling coal in this plant, although embodying nothing unusual, is nevertheless interesting and shows how the conditions were met by a simple and inexpensive arrangement.

As shown in Fig. 3, coal is brought in cars to a siding on a trestle at the opposite side of the road from the power house. Under this trestle is a concrete-lined tunnel connecting with the bottom of the elevator shaft. Coal is dumped from the railroad cars onto a pile around the trestle and from here through a hopper in the roof of the tunnel to hand cars. The latter are run over a narrow-gage track to the elevator and are raised to the level of the boiler-house roof. They are then run across a bridge, spanning the roadway, and distribute the coal to the bunkers located over the boilers. These bunkers are of such size as to hold a ton of coal per linear foot.

The entire operation requires the services of but one man who can in this way handle nearly 200 tons a day.

Plum Street Generating Station

When visiting Cincinnati one should not fail to inspect the Plum street station of the Union Gas and Electric Company. This plant has a capacity of 28,000 kilowatts and supplies electricity for light and commercial power to the entire city as well as to the various outlying districts. Although not a new plant, it is in many respects uptodate, and additions have been made to it from time to time.

A plant of 28,000 kilowatts capacity supplying light and commercial power to the city of Cincinnati. A new arc-lighting equipment is about to be installed and the contract covering this apparatus is the largest that has ever been given out at any one time.

Equipment

There are two boiler rooms, one a part of the original building and the other, which was added about five years ago. The former contains six Babcock & Wilcox, six Edge Moor, and two Stirling boilers, all equipped with American stokers. In the second boiler room there are eight 542-horsepower Stirling boilers set in batteries of two with Jones stokers and eight similar boilers equipped with American stokers. Coal is brought to the plant in wagons and is delivered onto a conveyer which raises and distributes it to the storage bins over the boilers.

Very little coal is used, however, as one set of eight boilers in the new part together with those in the old part are fitted with gas burners using natural gas; hence the coal is used only for banking and emergency purposes. There are 24 burners to a boiler, and the only alteration in the setting is that the ordinary coal grates are covered with tile. A view of one row of boilers with gas burners is shown in Fig. 3.

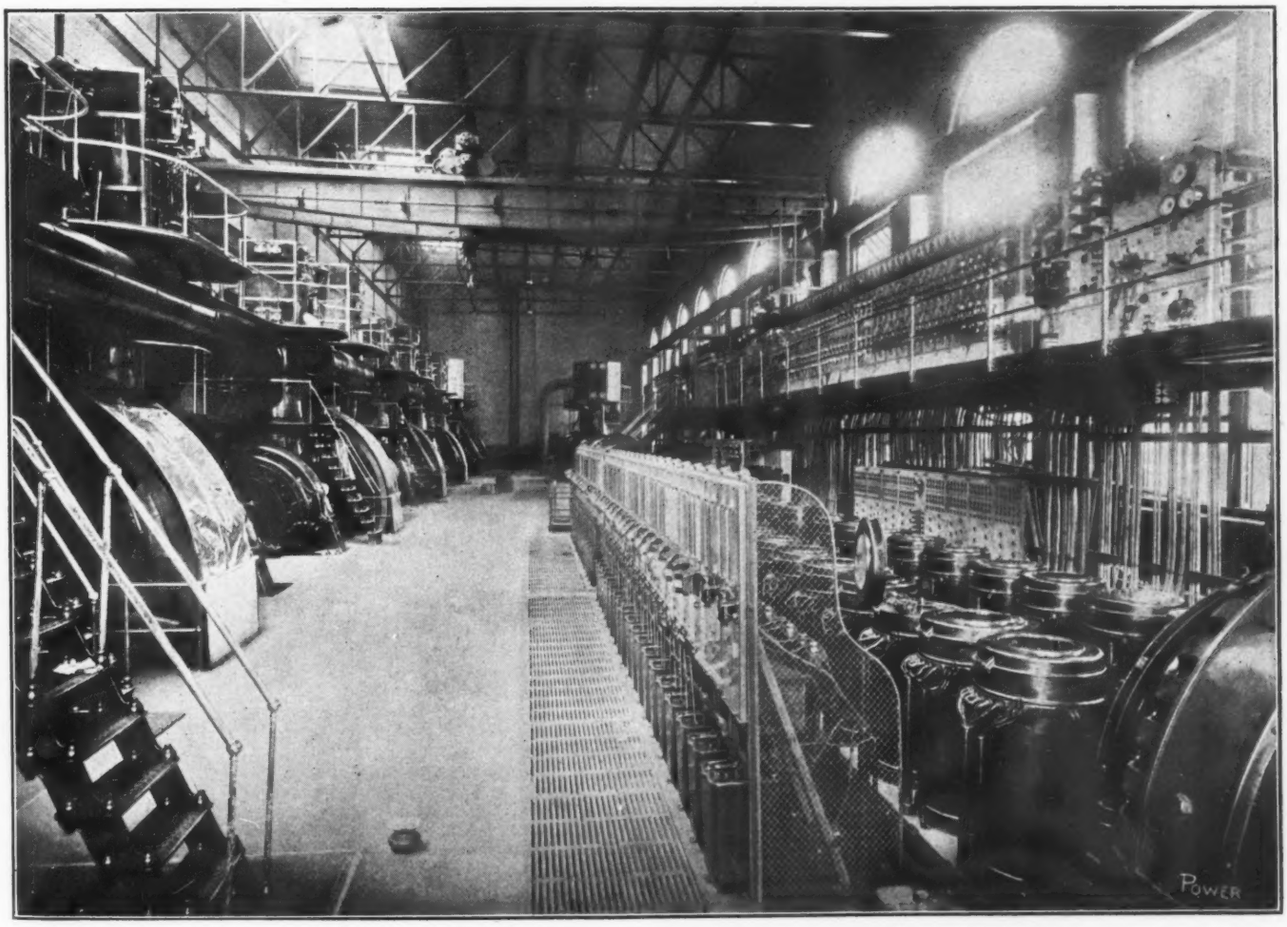


Fig. 1. Second Engine Room, Showing Switchboard

There are two engine rooms, one containing three large vertical engines and two turbines; the other a number of smaller engines of the vertical type, bal-

ancer sets, the main switchboards and the arc-lighting equipment. A view of the latter engine room is shown in Fig. 1.

Of the large units shown in Fig. 2, the first is a 3200-kilowatt, three-phase, 60-cycle generator direct connected to a vertical cross-compound Allis-Chalmers engine. The second is a 2500-kilowatt, 300-volt, direct-current machine driven by an engine of a type similar to the first. The third is a vertical cross-compound McIntosh & Seymour engine direct connected to one 125-volt and one 250-volt generator, these having a combined capacity of approximately 2500 kilowatts.

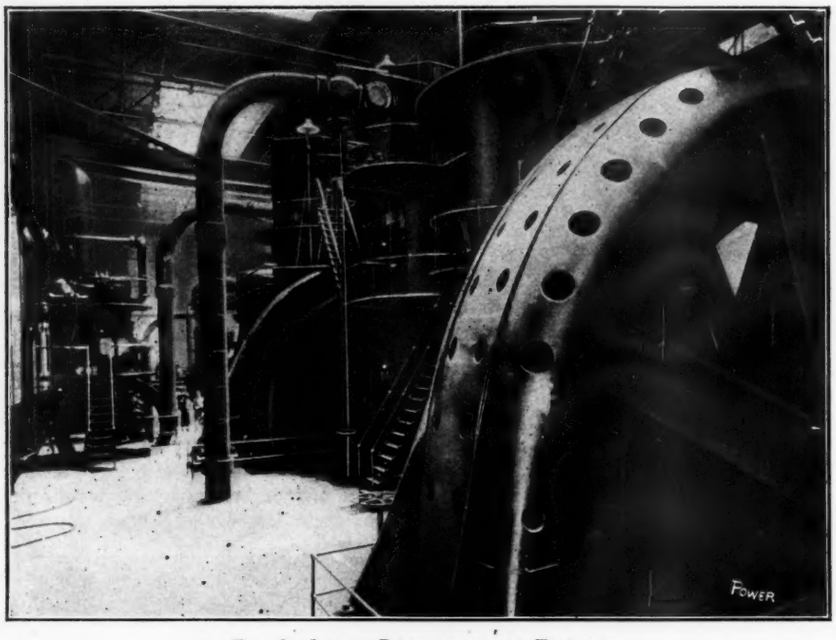


FIG. 2. LARGE RECIPROCATING ENGINES

In the second engine room are a number of sets of various capacities, the type consisting, for the most part, of a 4500-volt alternating-current generator on the shaft with a 250 to 300-volt direct-current generator and driven by a vertical cross-compound engine. In addition to these there are several motor-generator sets receiving three-phase alternating currents at 4500 volts and delivering direct current at 250 to 300 volts.

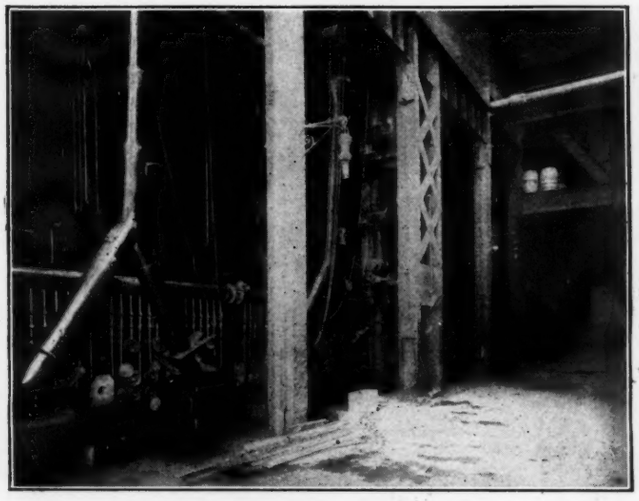


FIG. 3. BOILERS BURNING NATURAL GAS

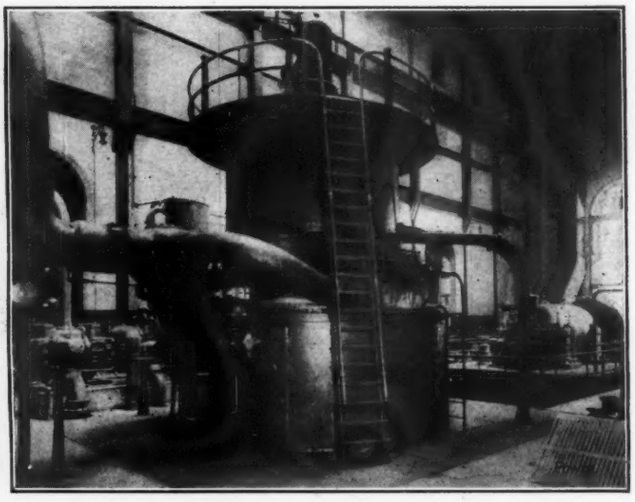


FIG. 4. TURBINES

At the far end of this engine room are two turbines, which are comparatively recent additions. As shown in Fig. 4, one is a 5000-kilowatt, 4500-volt, three-phase, 60-cycle Curtis machine running at 1800 revolutions per minute, and equipped with a Worthington condenser; the other is a 10,000-kilowatt, 4500-volt, three-phase, 60-cycle Westinghouse-Parsons machine, taking steam at 175 pounds and exhausting into a Leblanc condenser.

For commercial light and power within the city the three-wire system is used with 240 volts across the outside wires and 120 volts between either outside wire and the neutral. The suburbs are supplied with alternating current at 2300 volts, this being stepped down at the plant from the 4500 volts, which is the e.m.f. produced by the large generators.

At present the Wagner system of alternating-current series arc lighting is employed throughout the city, but this is about to be replaced by a General Electric direct-current series arc system. In this connection it might be well to note that the contract for this new arc-lighting equipment is the largest that has ever been let.

The specifications call for one hundred and twenty-eight 75-light mercury-vapor rectifier sets supplying 4-ampere luminous arc lamps, and four thousand 80-watt alternating-current series tungsten lamps for the business section of the town. In addition to this there are to be several sets of 60-watt lamps for boulevard lighting.

Of the equipment included in this contract all the rectifiers and 6000 arc lamps are to be installed immediately.

An Ideal Central Station

A recognized disadvantage of the average central station is the enormous loss due to distribution. To minimize this, high-voltage transmission is usually employed, but this necessitates the installation of more expensive equipment. Moreover, central stations usually have no market for their exhaust steam.

On the other hand, while the isolated plant does not incur the high distribution losses and usually has a demand for the exhaust steam during the greater part of the year, it often lacks a high load factor.

The ideal condition then is a central station supplying power to customers within a limited area in the immediate vicinity of the plant and selling the exhaust steam for heating and industrial purposes. Such is the colony plant at Oakley, O., a suburb of Cincinnati.

About three years ago the Cincinnati Milling Machine Company acquired a large tract of land at Oakley, to which it

moved its works. Parcels of this land were then sold to several other manufacturing firms, including the Triumph Electric and Refrigerating Company, the Modern Foundry Company and the Bickford Drill Company. A central power plant was erected to supply direct current at short-distance transmission for light and power and exhaust steam for heating and manufacturing purposes; direct current being selected on account of the individual machine-tool drive.

The plant is run virtually on a co-operative plan, each concern owning stock *pro rata* to the amount of power utilized during the year. That is, each consumer is billed at a fixed nominal rate and after deducting the operating expenses and 6 per cent. to cover interest charges, the surplus is rebated to the consumer according to the amount of steam and electrical energy consumed.

The present capacity of the plant is 1100 kilowatts, the equipment consisting of two 250- and one 500-horsepower Stirling boilers, equipped with Detroit stokers and furnishing steam at 135 pounds gage to one Ball & Wood compound engine driving a 600-kilowatt generator, an engine of the same make driving a 300-kilowatt machine and a Harrisburg Corliss engine driving a 200-kilowatt generator. In addition to these there is an air compressor having a capacity of 200 feet of free air per minute. All lines supplying customers are metered.

It is planned to add to the present equipment of the plant in order to meet the increased demand for power and a more detailed description of the plant will appear at a later date.

Saving with Low Pressure Turbine

A striking instance of the gain due to installing a low-pressure turbine in connection with high-pressure reciprocating engines, is to be found at the plant of the Western Ohio Traction Company at St. Marys, Ohio.

This plant, which is of approximately 3500 kilowatts capacity, supplies power to the interurban trolley system connecting Toledo, Lima, St. Marys and Wapakoneta and to local lines within those towns. Current is generated at 400 volts and the voltage is stepped up to 33,000 for transmission to the various substations where it is stepped down to 650 volts.

The installation of an 1150-kilowatt low-pressure turbine, taking steam from two reciprocating engines, resulted in a reduction from 4½ to 3½ pounds of coal per kilowatt-hour.

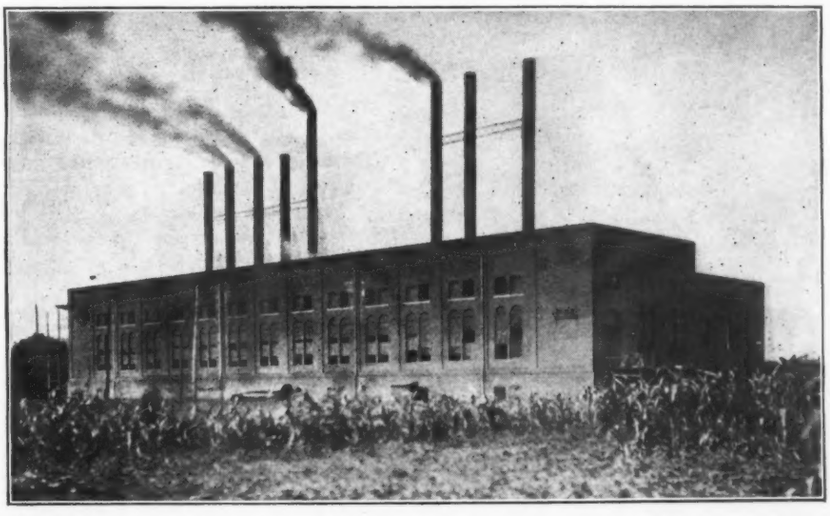


FIG. 1. EXTERNAL VIEW OF PLANT

The boiler plant of the generating station contains eight 375-horsepower Stirling boilers, five of which are served by Model automatic stokers and three are hand fired. These furnish steam at 150 pounds to two cross-compound Cooper engines, each connected to a 750-kilowatt generator and to two engines of the same type driving 400-kilowatt generators. The exhaust from one 750-kilowatt and one 400-kilowatt unit is led to a 1150-kilowatt low-pressure Westinghouse turbine. The latter runs on a vacuum of about 27 inches, maintained by a Leblanc condenser and air pump, and the back pressure on the reciprocating engines to which it is connected is approximately 3 pounds gage.

No complete plant tests have been made, but careful records are kept of the coal burned and of the electrical output at the switchboard. These have shown that, running at an average load of 50,000 kilowatt-hours per 24 hours, the low-pressure turbine has reduced the coal consumption from 4½ to 3½ pounds per kilowatt-hour. Of course, the latter figure is not exceptionally good; in fact, it is only about the average, and the 4½ pounds of coal per kilowatt-hour formerly consumed would be considered a very poor showing. The high coal consumption, however, is due to a poor quality of coal and to adverse conditions in the boiler room, and does not detract from the good showing of the low-pressure turbine.

A little calculation will show that this reduction of one pound of coal per kilowatt amounts to 50,000 pounds or 25 tons of coal a day. Assuming the price of coal to be as low as $1.60 a ton this saving would amount to $40 a day or over $14,000 a year. At this rate the turbine would pay for itself in about three years, a comparatively short time in which to cover the initial investment.

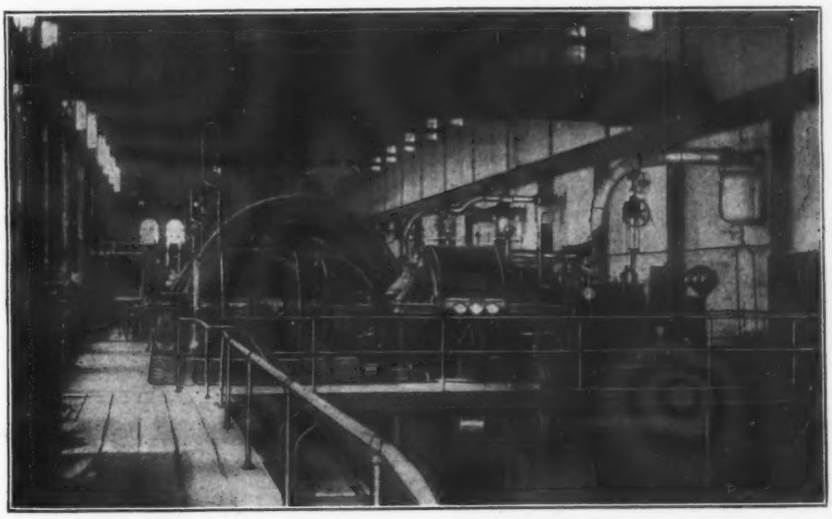


FIG. 2. LOW-PRESSURE TURBINE AND RECIPROCATING ENGINES

The Zoelly Steam Turbine*

The Zoelly turbine, when first introduced about fifteen years ago, was of the pure impulse type, based largely upon its designer's experience with waterwheels. The developments leading up to the present design are dealt with and its characteristic features are discussed.

*Abstract of a paper presented at the Zürich meeting of the Institution of Mechanical Engineers.

At the meeting of the Institution of Mechanical Engineers of Great Britain, recently held in Zürich, a paper under the above title was presented by H. Zoelly, engineer and director of Escher, Wyss & Co., of that city, inventor of the turbine which bears his name.

Guided largely by the knowledge gained in his experience as a designer of water turbines, in which line he has specialized for twenty-five years, the author commenced about fifteen years ago to experiment with steam turbines. In water turbines the impulse type is used for everything above 300 feet head, and he, considering the steam turbine analogous, was naturally led to the pure action or impulse type for the high velocities involved in the steam-driven machine.

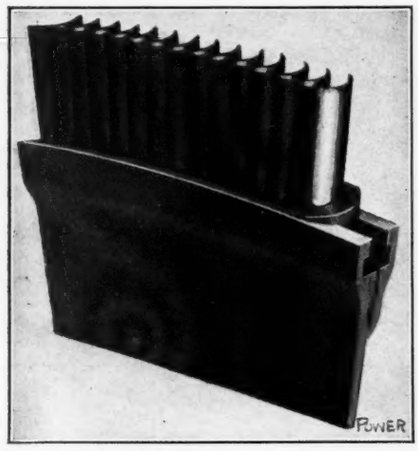


FIG. 1. ROTOR BLADES

The first machine was designed on the radial-flow principle, but in its design too much attention was paid to considerations of construction and too little to theory.

The second machine was constructed with curved blades instead of the flat ones previously used, but the steam, in this case also, impinged upon the blades in a radial direction. It was found advisable to divide the pressure drop into at least six and sometimes into ten or twelve stages. The diameters of the rotors were increased toward the exhaust end in order to better cope with the increased volume of steam.

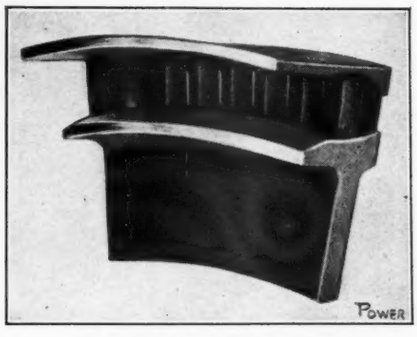


FIG. 2. GUIDE CHANNELS

The only alterations which occurred for some time were in the manner of guiding the steam on to the wheels. The first construction used was similar to that of the Pelton waterwheel, the steam impinging tangentially after having been directed through separate guide channels. It soon became apparent, however, that after impact the steam became too much dispersed. It was then decided to expand the steam axially instead of radially, at first only in the low-pressure stages but subsequently throughout the turbine. This method had previously been adopted by English constructors as being the most practical.

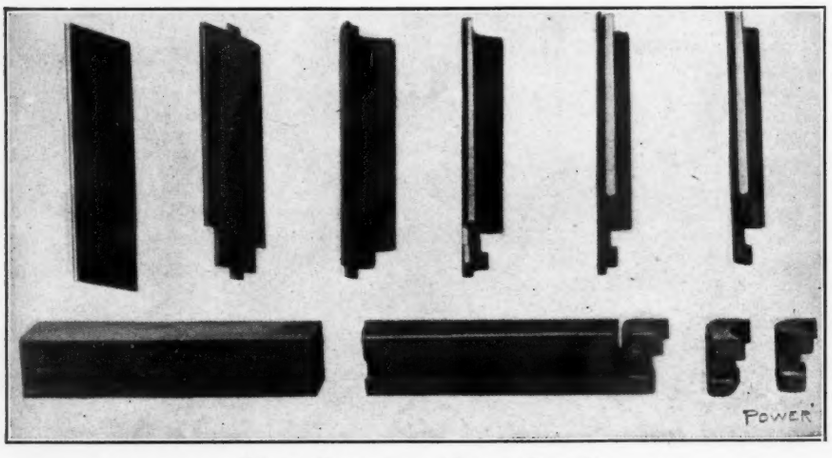


FIG. 3. PROCESS IN MAKING BLADES

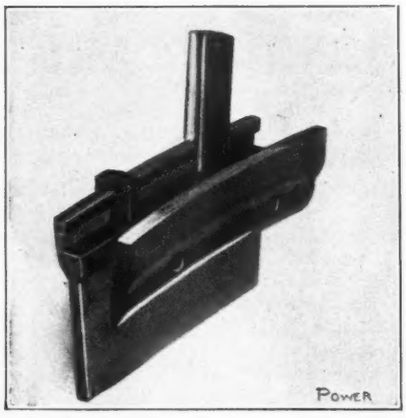


FIG. 4. ASSEMBLING ROTOR

What has always been, and is still, the most characteristic feature of the Zoelly turbine is the design of the rotor blades and of the guide channels, shown respectively in Figs. 1 and 2. Fig. 3 shows the successive operations in making the nickel-steel blades in which they are assembled. Constructed in this way the wheels are capable of being run at a relatively high circumferential velocity, permitting greater latitude in re-

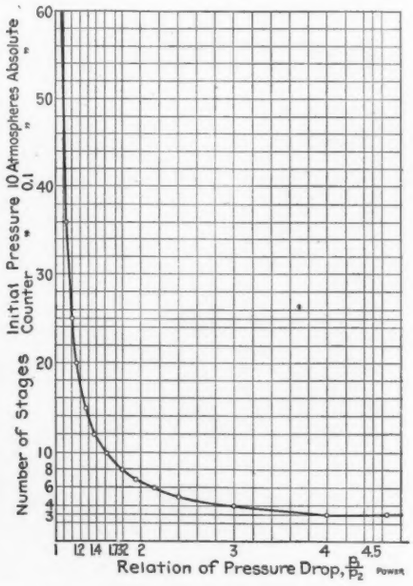


FIG. 5. STAGES REQUIRED FOR EXPANDING FROM 10 ATMOSPHERES TO FINAL PRESSURES

gard to the number of stages and the velocity of the steam in each.

From the start two characteristic diagrams have been employed. They were plotted from theoretical calculations, which have since been proved by actual results. In Fig. 5 the abscissas are the pressure relations per stage $\frac{p_1}{p_2}$ where p_1 equals the initial steam pressure and p_2 the final steam pressure both in atmospheres absolute in the same stage. The ordinates are the requisite number of stages for steam expanding from 10 atmospheres, with varying values of $\frac{p_1}{p_2}$, assuming that ratio to be constant both before and after passing through the guide channels. That reproduced in Fig. 6 shows the steam velocity resulting from various ratios of expansion from various initial pressures. Fig. 5 shows, for instance, that about nine stages are required for the critical pressure ratio

$$\frac{p_1}{p_2} = 1.732$$

For the relative pressure falls, where $\frac{p_1}{p_2}$ is as indicated, the requisite corresponding number of stages for a total expansion of from 10 to 0.1 atmospheres absolute would be as follows:

$\frac{p_1}{p_2}$ =	1.1	1.2	1.3	2.1	3	4.6
Stages	42	25	18	6	4	3

From Fig. 6 for a mean initial pressure of

$p = 4$ *atmospheres absolute,*

the steam velocity would be equal to 577* meters (1893 feet) per second. This steam velocity, on the other hand, would require a circumferential speed of about 250 meters (820 feet) per second for a simple velocity wheel in order to obtain a reasonable efficiency. If a smaller ratio of pressure fall than $\frac{1.732}{1}$,

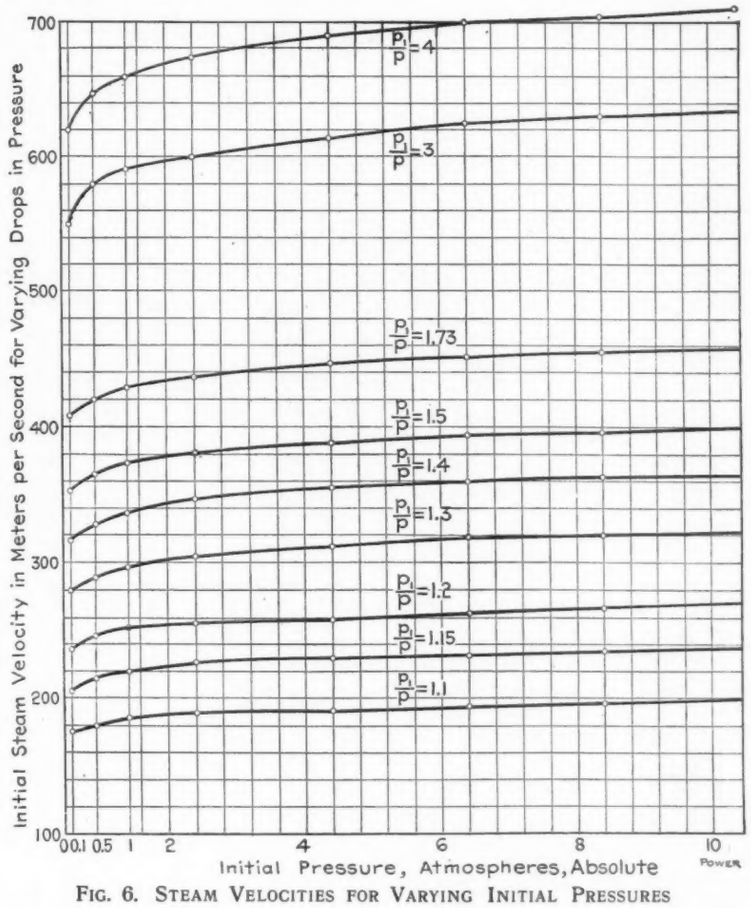


FIG. 6. STEAM VELOCITIES FOR VARYING INITIAL PRESSURES

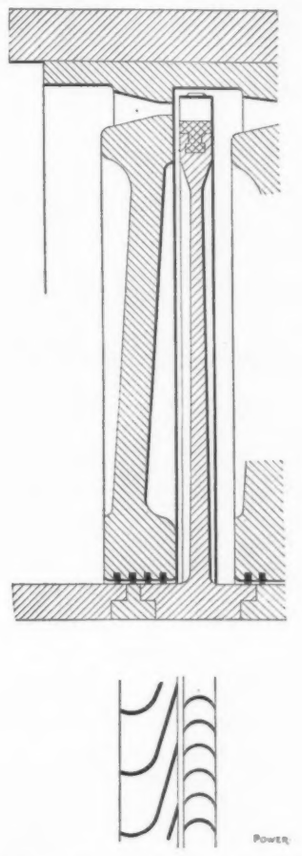


FIG. 7. SINGLE VELOCITY STAGE

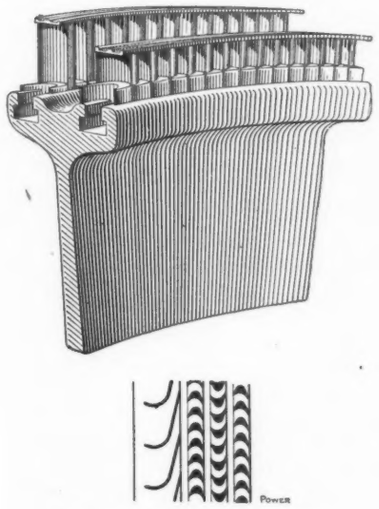


FIG. 8. COMPOUND WHEEL

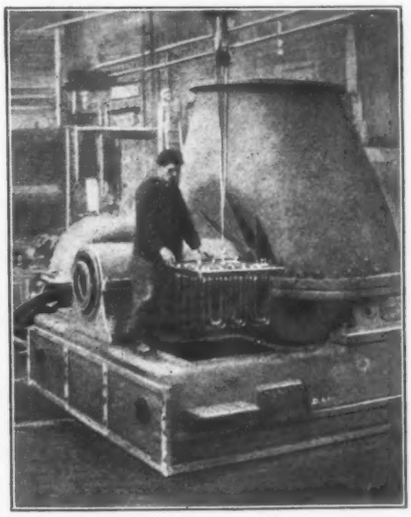


FIG. 9. OIL-COOLING SYSTEM

*There is some confusion in this paragraph. The velocity acquired by dry saturated steam in expanding from an initial pressure of four atmospheres, 58.8 pounds, to $58.8 \div 1.73 = 34$ pounds (say from 291 to 257 degrees) is about 1450 feet or 442 meters per second. Just about what is shown for $p_1 \div p_2 = 1.73$, and $p = 4$ in Fig. 6. As this is the ratio and initial pressure which the author appears to be discussing, and as none of the curves cut the four-pound initial ordinate at anywhere near 577 meters, the reference is difficult to understand.—EDITOR.

for instance, $\frac{1.30}{1}$ be taken, the necessary number of stages would be increased from 9 to 18; that is, exactly doubled. Such a turbine would be far too complicated and expensive. Besides, it would not then work with the best economy, owing to the greater friction of the runner wheels and the greater length of steam passage involved.

After carefully weighing all these considerations the ratio of

$$\frac{p_1}{p_2} = 1.73$$

was chosen for the pressure fall per stage, as representing the best combination of efficiency and practical constructional economy. This is called the critical ratio. When it is exceeded, the resulting steam velocity approaches that of sound. It is the highest velocity obtainable in the throat of a nozzle. Directly one wishes to utilize a substantially higher pressure fall per stage, it becomes necessary to depart from the simple construction of parallel guide blades, which is characteristic of the Zoelly turbine, and to adopt the expanding or De Laval type of nozzle. The reason that Parsons employs such a small pressure fall per stage is to keep down the losses through leakage, which are unavoidable in reaction turbines.

For turbines of 3000 revolutions per minute eight stages are usually employed by Escher, Wyss & Co.; for 1500 revolutions per minute, 12 stages, and for 1000 revolutions per minute 16 stages. The first diaphragm plate of the high-speed turbine has guide passages or nozzles which extend for a portion of the circumference only in the bottom half of the diaphragm, while in the other diaphragms the nozzles or guide passages usually extend completely around the circumference. In the case of large units, however, the entire circumference is used for admission in all stages.

The governing is effected simply by throttling the live steam and not by varying the number of channels through which the steam is admitted. The throttle valve is actuated by oil under pressure in a small cylinder (servo-motor), the oil being supplied by a small pump driven directly from the shaft. This is the method of governing that has been found to work so successfully for water turbines, and is now being adopted by nearly all the makers of steam turbines on the Continent. Its inherent advantages are that it is extremely simple and reliable and, contrary to fears expressed by some engineers, works particularly economically at partial loads, as shown from the results set forth in the accompanying table. This, however,

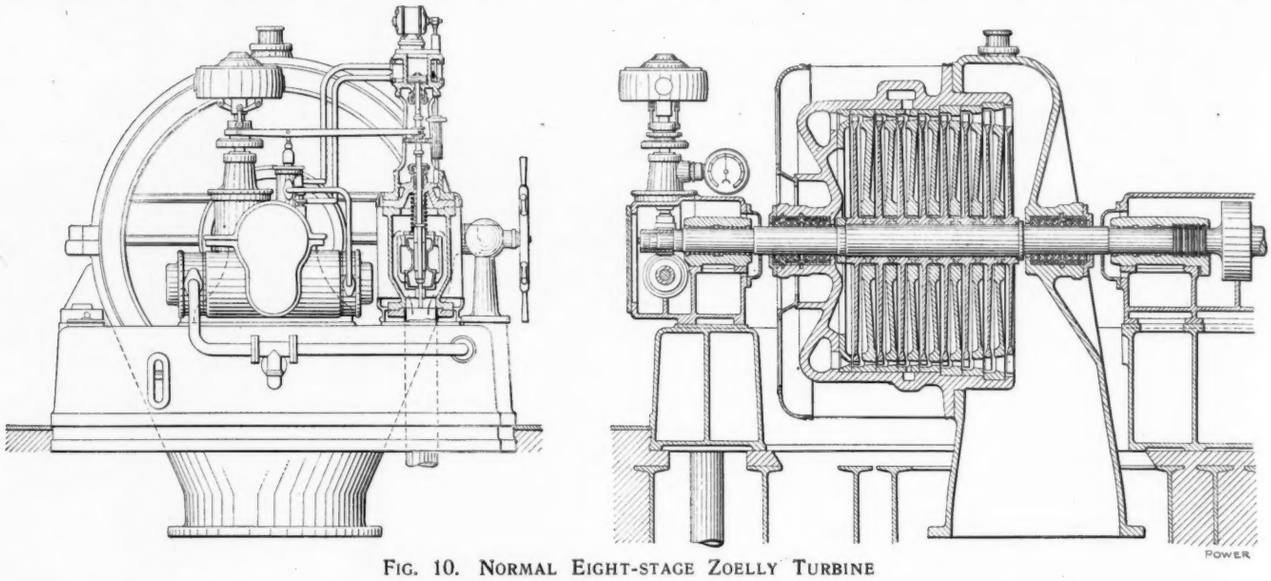


FIG. 10. NORMAL EIGHT-STAGE ZOELLY TURBINE

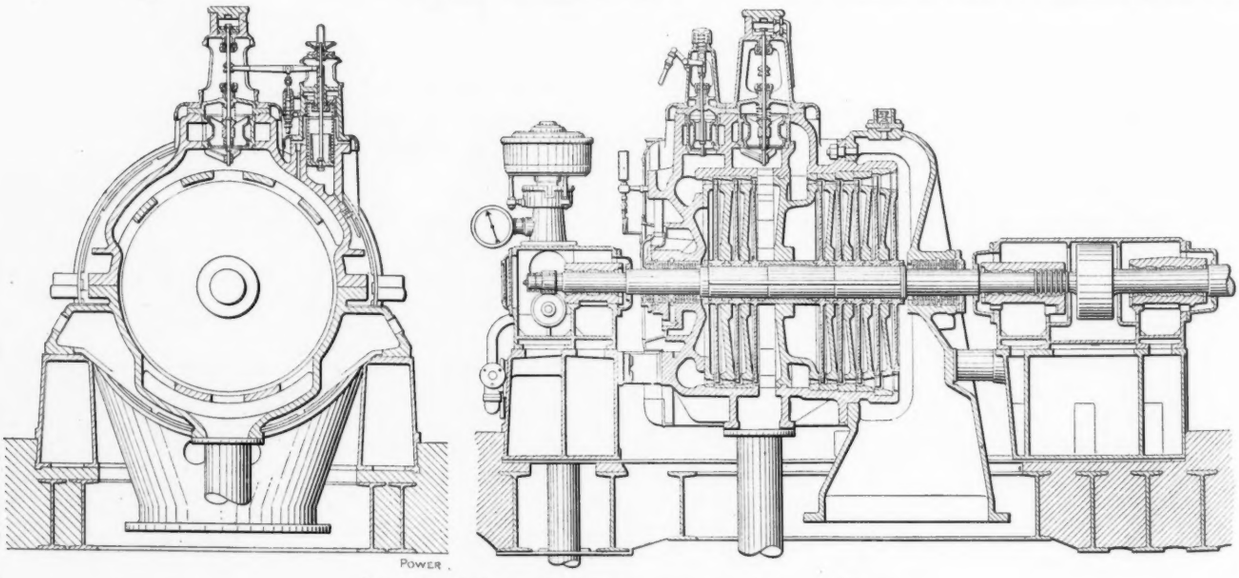


FIG. 11. EIGHT-STAGE TURBINE WITH BLEEDER DEVICE

is possible only when simple velocity wheels are used in connection with parallel guide nozzles throughout the turbine, and provided that the most favorable choice is made in regard to subdivision of stages. Fig. 7 illustrates a simple velocity stage in the Zoelly turbine, showing a section of the blading. The conclusion at which the author has arrived is that the compound-velocity wheel design is advisable only in special cases, as, for instance, in marine work, where a low propeller speed is absolutely necessary. Fig. 8 illustrates a portion of a compound-velocity wheel and a section of the blading.

The chief reasons against the adoption of the compound-wheel design in the case of stationary turbines are the lower steam efficiency and the necessity of a complicated governing apparatus in order to obtain a favorable consumption at partial loads. In this type of turbine the governing has to be carried out by controlling the number of nozzles through which the steam enters. Experience has shown that this method does not satisfactorily answer practical requirements; that is, continuous safe running. Besides, the governing is not as accurate, and is less suitable for running in parallel with other machines. The author says that he has for many years experimented with turbines designed with high steam velocity and compound wheels, and that the many series of tests which he has carried out at different periods have all gone to show that under the most favorable conditions it is not possible to obtain a higher thermal efficiency than 58 per cent., with compound-velocity wheels, whereas with a turbine designed entirely with simple velocity stages it is possible to obtain an efficiency of 75 per cent. and more. If, therefore, in an impulse turbine it is found necessary to employ a combination design of compound- and single-velocity stages for such special cases as exceptionally large units for land purposes, or where it is necessary to work at low rotative speed, the comparatively poor efficiency of the high-pressure compound-velocity stage or stages must be compensated for, as far as possible, by obtaining a relatively higher efficiency in the subsequent low-pressure single-velocity stages. For this purpose almost as many pressure stages must, on the whole, be provided as in a design employing only single-velocity stages.

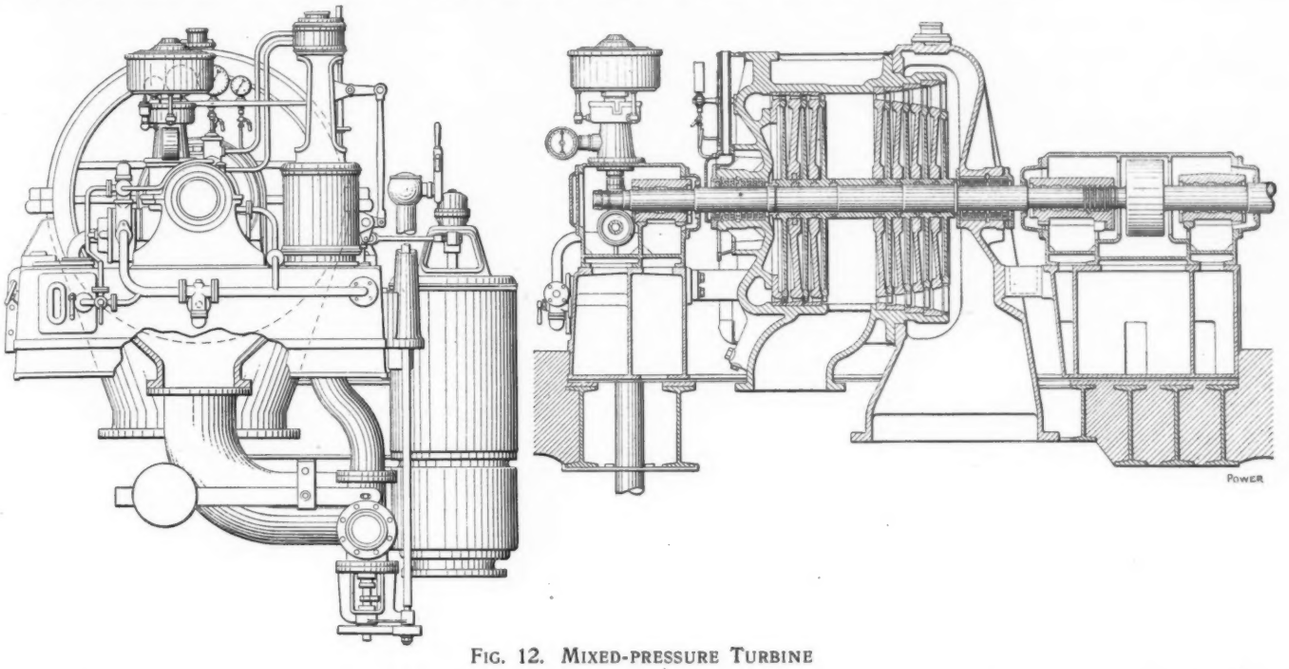


FIG. 12. MIXED-PRESSURE TURBINE

It is often objected that in the Zoelly turbine too high a pressure and temperature exist in the first pressure stage; but Mr. Zoelly contends that even with single-velocity stages large pressure falls can be utilized for the first stage within comparatively economical limits, provided the lower-pressure or subsequent stages have a correspondingly

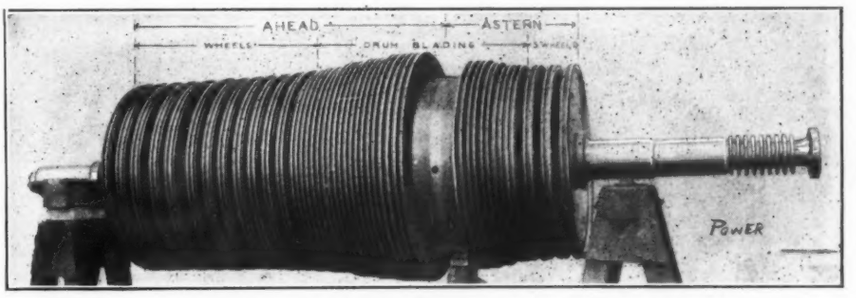


FIG. 13. ROTOR OF MARINE TURBINE

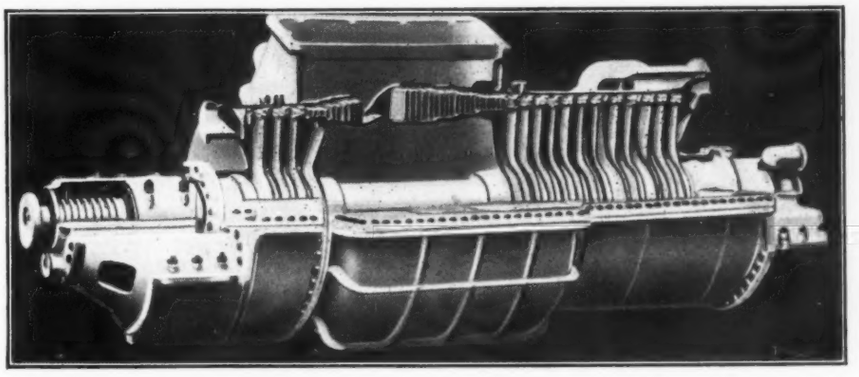


FIG. 14. SECTION OF MARINE TURBINE

lower pressure fall, and thus work with a higher efficiency. With an initial pressure of about 170 pounds per square inch and a temperature of 550 degrees Fahrenheit (300 degrees Centigrade), the pressure and temperature of the steam after expansion in the first stage is 70 pounds per square inch and 465 degrees Fahrenheit (240 degrees Centigrade). Such conditions so far as they affect the rigidity and durability of the casing, and the tightness of the stuffing boxes, are nowadays easily mastered by steam-turbine builders.

The Zoelly turbine has from the commencement been constructed with a horizontal shaft; experience with water turbines having shown that by this method the simplest form of bearing can be used, permitting an easy inspection at all times. In the case of turbines running at 3000 revolutions per minute a flexible shaft is used, so that the critical speed is sufficiently below the working speed; but in the case of turbines running at 1500 revolutions per minute and under the shaft is rigid and the critical speed is above the working speed. The shaft is supported upon two bearings, which are lubricated by oil under pressure, and is connected by means of a rigid or flexible coupling (usually rigid) to the generator or machine to be driven. The casing is built in halves, the joints being horizontal, so that the rotor can be inspected or removed without dismantling the bearings. The oil-cooling coils are located in the base, and are shown in Fig. 9 ready to be lowered into position.

Some results of recent tests are given in the accompanying table. They were made with carefully calibrated instruments by competent and impartial observers. Particular attention is called to the manner in which the efficiency is maintained at partial loads. The thermal efficiency is referred in one case to the steam as actually supplied to the turbine, and to the other in a throttled condition behind the stop or throttle valve.

Fig. 10 shows a section of a normal eight-stage Zoelly turbine, constructed to develop 1500 to 1800 horsepower at 3000 revolutions, with a steam pressure of 170 pounds, at 570 degrees Fahrenheit, and with a vacuum of 95 per cent.

Fig. 11 shows sectional elevations of an eight-stage Zoelly turbine, fitted with a connection for drawing off about 4500 pounds of steam per hour, at a pressure of 3 to 5 pounds, for heating and for other purposes. This turbine was constructed for the Zurcher Papierfabrick, Sihl, to develop about 1100 horsepower at 3000 revolutions per minute, with an initial steam pressure of 115 to 120 pounds, at a temperature of 570 degrees Fahrenheit, and with a vacuum of 95 per cent.

Fig. 12 shows a section and elevation of a mixed-pressure Zoelly turbine, constructed for Zehe, Dannenbaum, to develop 1800 horsepower at 3000 revolutions per minute, with a main steam pressure of 115 to 125 pounds, using exhaust steam at a pressure from 5 to 12 pounds, and with a vacuum of 91 per cent.

The high-pressure portion of the Zoelly marine turbine is fitted with a series of compound-velocity wheels. Fig. 7 illustrates a portion of one of these wheels and a section of the blading. Owing to the low rotative speed required single-velocity wheels cannot be utilized to their full advantage. To obtain a reasonable efficiency with a single-velocity wheel would allow of only a very small drop of pressure in each stage, which would necessitate far too many stages. Furthermore, contrary to the theories put forth by Curtis, it was found advisable to adopt the ordinary parallel guide channels, similar to those used in the Zoelly land turbine, in preference to expanding or De Laval nozzles; a type of construction which has since proved its merit. The high-pressure portion of these turbines, therefore, consists of a series of compound wheels, the low-pressure portion of impulse drum blading.

Messrs. Escher, Wyss & Co. have recently built in their workshops at Zürich a set of two marine turbines, each of 7500 horsepower, which are now in operation in the torpedo boat destroyer "G 173" of the imperial German navy. These turbines are illustrated in Figs. 13 and 14. Fig. 13 shows the rotor complete, and Fig. 14 the section of a turbine. A number of similar turbines are now being constructed for the German, French, American, Italian and Argentine navies.

In conclusion, the author acknowledges his indebtedness to Mr. E. R. Peal, engineer of the British Zoelly Turbine Syndicate, for assistance rendered in preparing the paper.

TESTS OF ZOELLY STEAM TURBINES

Installation	Load in Kilowatts	Steam-pressure at Stop Valve: Pounds per Square Inch	Steam-pressure at Stop Valve: Temperature, Degrees F.	Vacuum	Steam Consumption: Kilowatt-hour	Steam Consumption: Horsepower-hour	Thermal Efficiency, Per Cent. Based on Condition of Steam: in Front of Stop Valve	Thermal Efficiency, Per Cent. Based on Condition of Steam: Behind Stop Valve
				Per Cent.	Lb.	Lb.	Per Cent.	Per Cent.
4000-kilowatt turbine	4189	164.7	556.7	95.8	*13.25	9.36	68.7	71.2
"Charlottenburg"	3092	168.3	558.3	96.2	13.77	9.58	66.2	70.8
1000 revolutions per minute	2199	161.9	518.5	97.4	14.40	9.84	63.2	70.75
Tested December, 1910	1138	166.9	520.7	97.8	16.00	10.12	59.9	72.7
2000-kilowatt turbine	2052	179.0	584.6	94.9	13.04	9.18	70.5	73.0
"Helsingfors"	1514	181.7	563.3	95.5	13.67	9.52	67.2	72.8
3000 revolutions per minute	1026	177.5	565.5	95.8	14.53	9.76	65.2	73.8
Tested November, 1910	510	171.8	543.0	96.6	17.33	10.68	58.8	72.8
1700-kilowatt turbine	1691	206.0	670.2	93.3	13.04	8.91	69.7	69.8
"Hagendingen"	1366	202.3	673.5	94.2	13.77	9.18	66.5	69.2
3000 revolutions per minute	851	205.2	662.0	95.2	15.52	9.81	61.0	66.9
Tested December, 1910	457.5	208.0	642.9	94.9	18.91	10.68	57.1	67.9
1200-kilowatt turbine	1235	162.3	451.0	94.0	15.34	10.77	67.0	68.3
"Aurich"	949	164.0	442.4	95.5	15.99	11.08	62.8	66.9
3000 revolutions per minute	606	166.7	427.4	96.5	17.1	11.48	59.0	66.6
Tested December, 1910	—	—	—	—	—	—	—	—

*Not including steam required for condensing plant.

Central Engine Room Oiling System

There was a time when an engineer or an oiler with an oil can in his hand was a familiar figure about a power plant. Beside the engine cylinder there was a stand on which were several polished oil cans of various sizes and types.

But hand lubrication was not always reliable. Sometimes the oiler became inattentive, and the oil cup ran empty; there was a hot box; not infrequently new babbitt was necessary.

Oiling methods have passed through various stages of evolution. The variety of oil cans has largely been displaced by individual or unit oiling systems, and even these have been supplanted in large engine rooms by one central oiling system capable of lubricating all of the machines in the plant.

An installation of this character has been placed in the power plant of the new Whitehall building, New York City, wherein every machine in the plant is automatically lubricated from a central source of supply.

There are three 500- and one 250-horsepower Rice & Sargent tandem-compound engines direct coupled to three 300-kilowatt and one 150-kilowatt direct-current generators respectively. The cylinders of these engines are each equipped with a four-feed Richardson Model "M" oil lubricator, as shown in Fig. 1. One pipe discharges to the steam passage of the high-pressure cylinder;

a second pipe conveys oil to the piston rod and the other two supply oil to lubricate the steam valves. On the low-pressure cylinder the piston rod on both sides of the cylinder is lubricated.

The Model "M" lubricator was designed with the special object in view of introducing some oil for every stroke of the engine. This is accomplished by employing an oil-pump plunger for each feed line, and no matter at what rate the oil is being fed through the sight-feed nozzle of the lubricator, this oil plunger moves up and down in unison with the strokes of the engine and chops off a small particle of oil and forces it to the cylinder at each revolution of the engine.

The bearings, eccentrics and other parts requiring oil are all lubricated from the same central system. Oil cups, however, have been provided so that in case of emergency oil can be supplied to the bearing, etc., independent of the oiling system.

There is a motor-driven direct-current generator used for charging the storage-battery system. The bearings of this unit are supplied with oil from the

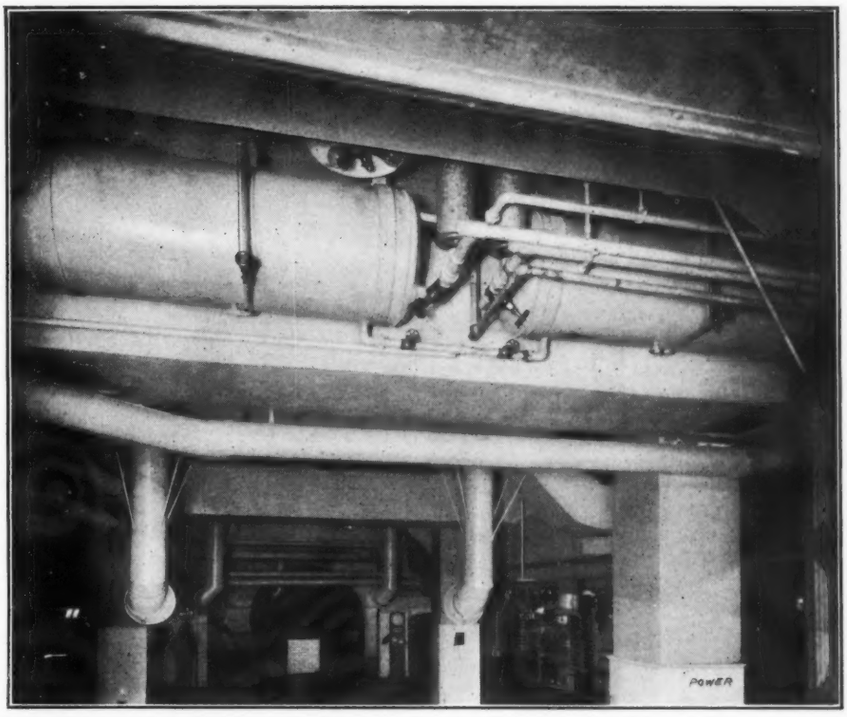


FIG. 2. SUPPLY TANKS SUSPENDED FROM THE CEILING

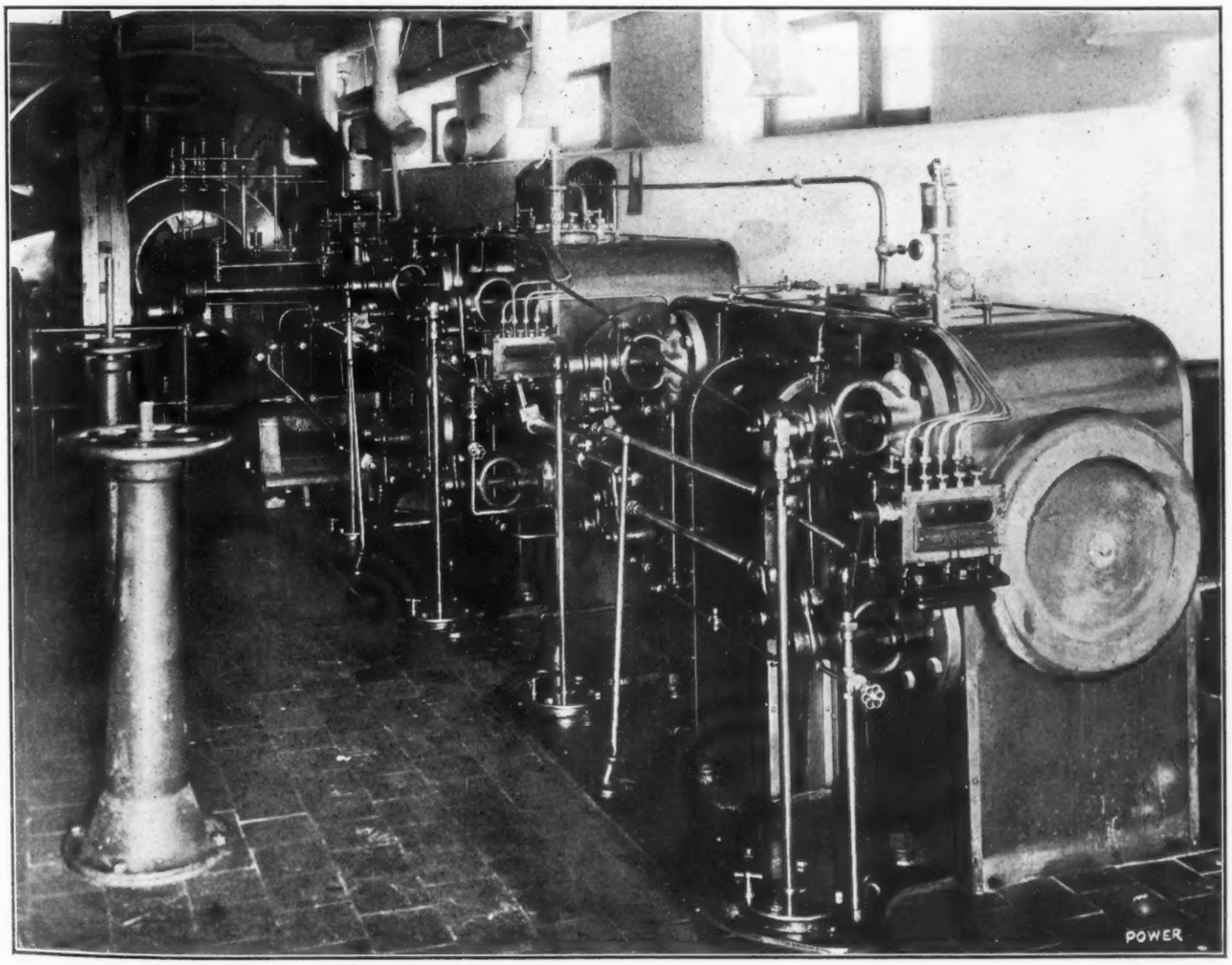


FIG. 1. OIL PUMPS ATTACHED TO ENGINE CYLINDERS

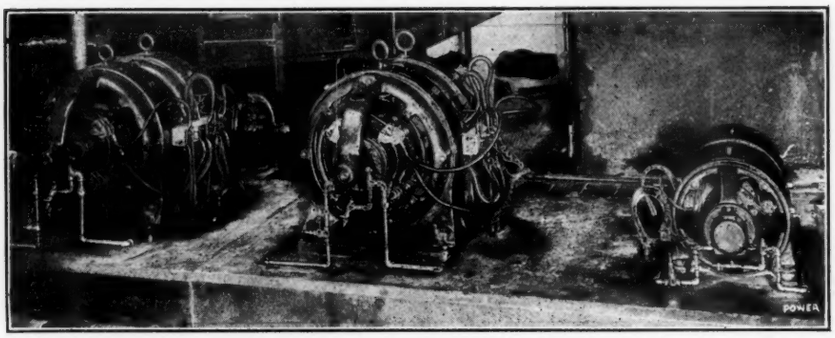


FIG. 3. EXCITER AND BALANCER SETS, SHOWING OIL SEALS ON THE BEARINGS

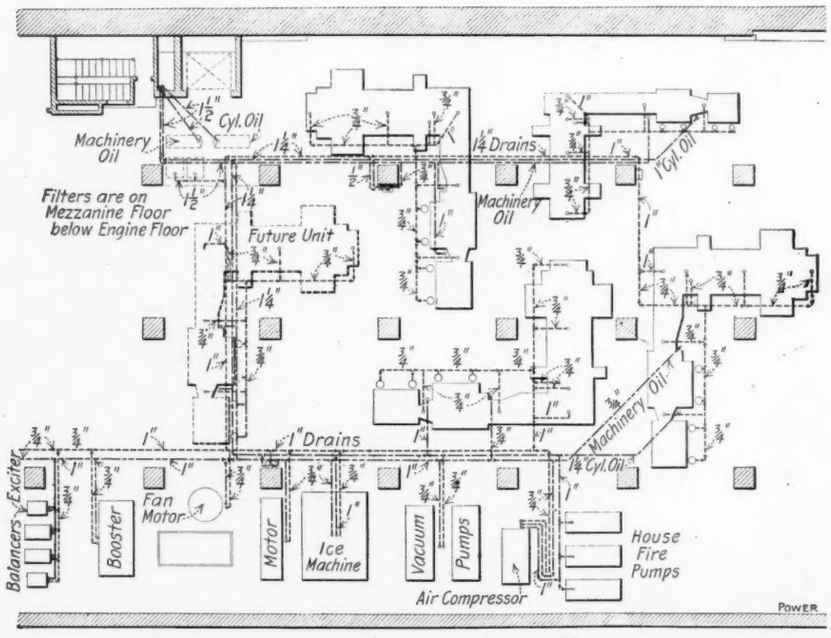


FIG. 4. PLAN OF OIL-SUPPLY PIPES TO MACHINERY

general oiling system. A proper oil level is maintained by an oil-seal arrangement similar to that in Fig. 3, which shows the balancer and exciter sets. The bearings are all equipped with gage glasses.

A plan view of the oiling system and connections to the various machines is shown in Fig. 4. All pipe lines represented by short dashes indicate drain pipes. Those shown by a long and short dash represent cylinder-oil pipes, and those shown by a long and two short dashes are machinery-oil pipes.

These oils are supplied to the system from two oil tanks suspended from the ceiling of the engine room, Fig. 2, high above any point to be lubricated. Each oil tank has a high- and low-oil alarm system which registers on an annunciator located on the mezzanine floor below the engine room. Each tank is fitted with a gage glass to designate the hight of oil in each independent of the alarm system.

After the oil has passed through the system it is returned to two Richardson-Phenix oil filters, each equipped with a high- and low-oil alarm which registers on the annunciator.

Oil is pumped to the overhead storage tanks by either of two triple-plunger motor-driven oil pumps shown in Fig. 5, through a 1-inch pipe. The drain pipes to the filter are 1½ inches in diameter as are also the feed pipes for both machinery and cylinder oils. When new oil is to be pumped into the storage tank from barrels a hose is coupled to the suction pipe of either pump and the other end put in the barrel. It is possible to use either pump by manipulating suitable Nelson valves with which the system is fitted. An elevation of the system which was designed and installed by the Peterson Engineering Company is shown in Fig. 6.

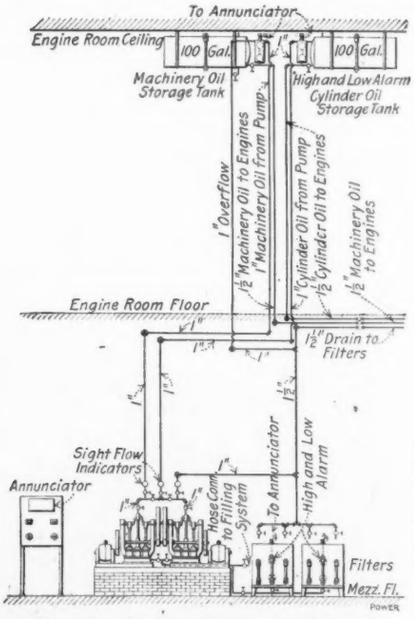


FIG. 6. ARRANGEMENT OF PIPING

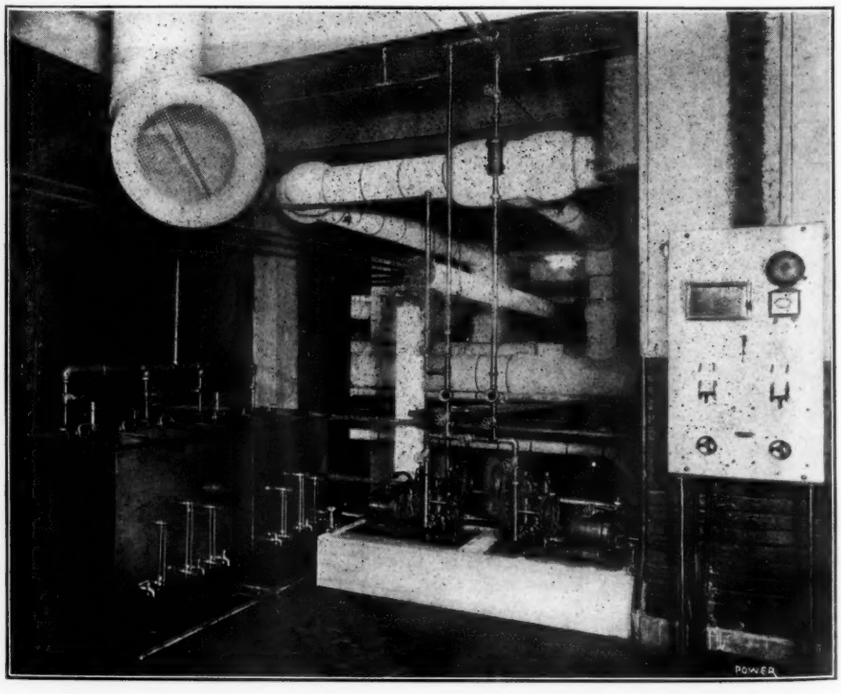


FIG. 5. OIL PUMPS AND FILTERS

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Operating Alternately on the Two Wire and Three Wire Plans

By Louis T. Kaiser

The Mercantile Library building in Cincinnati, Ohio, a 12-story office building, formerly contained a power plant consisting of boilers, hydraulic elevator pumps and two 100-kilowatt, 110-volt direct-current generators, direct-connected to tandem-compound engines. These generators supplied current to 2400 incandescent lamps, a 15-horsepower motor operating a refrigerating machine and four 4-horsepower motors driving ventilating fans. The switchboard consisted of two generator panels, an instrument panel and two panels carrying the switches and fuses for the various circuits, making five panels in all.

The St. Paul building, a 10-story structure located half a block distant, is owned by the same people The power plant of this building being old and out of date, it was decided to abandon it and obtain power from the Mercantile Library building. Accordingly conduits for both steam and electricity were laid from one building to the other, and in the St. Paul building were installed two traction-type Otis electric elevators, operating on direct current at 220 volts. About 1200 lights are used in the St. Paul building, in addition to several motors for driving house service pumps.

This additional demand for power made it necessary to enlarge and alter the plant in the Mercantile Library building. In order to supply the second building economically, a change was made from 110 to 220 volts and the equipment was increased by installing a 220-volt direct-current Crocker-Wheeler generator of 200 kilowatts capacity, direct-connected to a Ball automatic cutoff engine, a motor balancer set having a capacity of 300 amperes in the neutral wire of a three-wire system, and five additional switchboard panels.

Of the additional panels one contains the necessary switches and instruments for connecting the two original 110-volt generators in series and into service with the 220-volt busbars of the three-wire system; another panel contains the switches and rheostat for controlling the balancer set; a third carries the circuit-breaker for the feed wires supplying the St. Paul building; the fourth carries a watthour meter for recording the output of the entire plant when operating at 220 volts on the three-wire plan, and the last panel contains the generator switches, rheostat, etc., for the 220-volt machine.

The conditions of service are such that from midnight to 7 a.m. no motors or elevators are in operation. Hence, no 220-volt service is required, and the lighting load being small, there is very little loss in transmission. Therefore, the entire system is run at 110 volts.

Fig. 1. Front View of Switchboard

To provide this flexibility of operation, a very interesting arrangement of switchboard wiring is employed. This is shown diagrammatically in Fig. 2.

Operation

If the generator *A* is to carry the load in connection with the balancer set, the switches 1, 3, 4, 5 and 6 are closed, which allows the machine to operate with a compound field winding. By closing the switches 2 and 7, the compounding is cut out and the machine is operated with the shunt field winding only.

If it is desired to shift the load to the generators *B* and *C*, they are started and their e.m.f. adjusted to 110 volts. The switches 8 and 10 are then closed and the voltage is again adjusted to correspond with that of the 220-volt busbars. Next, the switches 11 and 12 are closed, which puts the generators *B* and *C* in series and in parallel with the generator *A*. They will not remain in parallel long, however, on account of the compound field windings. By closing the switches 2, 9 and 13, the compound field windings are short-circuited and all the generators operate as shunt machines. Cutting out all the switches on the generator *A* throws the entire load over to the generators *B* and *C*. The next step is to close the switch 14 and open the switches 6, 7, 5 and 4, which shuts down the balancer set and puts the unbalanced load on either

generator *B* or *C*, depending upon which side is out of balance.

For night service all the switches on the generator *C* are cut out and the switch 15 is closed; this throws the entire system on 110 volts.

This building has a large café which requires light all night, and the circuit supplying this café is tapped between the busbars marked *F*. By means of this arrangement the service is never interrupted. All switches are protected with circuit-breakers, and where necessary with those of the overload reversal type, protecting the entire system should the attendants throw in the wrong switch.

To change back to 220 volts, the generator *C* is started; after it has reached its proper voltage and the switch 15 is opened, the switches 11 and 10 are closed.

If the generator *A* is to carry the load, the balancer set is first thrown in, and then the generator; after it has reached its proper voltage, the generators *B* and *C* are cut out.

A storage-battery plant, said to be the largest single-battery plant of its kind in the world, will be erected by the Consolidated Gas, Electric Light and Power Company, of Baltimore, as soon as a building now being constructed for it is finished. The building will adjoin the largest direct-current substation of the company, and will cost about $50,000, while the entire cost of the plant will approximate $300,000. The storage battery will be of sufficient size to provide for the peak load in the entire business district for nearly half an hour should an accident occur at the time of maximum consumption.

By developing the unused water powers, the New York Water Supply Commission estimates that New York would derive a net annual income of $7,000,000 from leases granted to small power plants and machine shops.

Undercutting Commutator Mica and Removing Bad Spots

By Gordon Fox

The commutator is the cause of more than 75 per cent. of the troubles with direct-current motors. The most usual complaint is excessive sparking, resulting in rapid brush wear and blackening and heating of the commutator, possibly causing the solder in the risers to melt and become dislodged.

It is impossible to obtain satisfactory commutation on some motors. Often the sparking is just sufficient to pit the copper, cause high mica and start the commutator on its downward way. When it is impossible to prevent all sparking, even with the motor in good condition, it is often possible to reduce its destructive effect by slightly undercutting the mica. Various methods have been used for doing this. An excellent method is to "plane" the mica off with a 6-inch three-cornered file; one with considerable belly and a decided taper toward the end is preferable. This is broken off about an inch from the end and the new end is ground square on an emery wheel, care being taken not to mark the sides. The commutator is first trued up and smoothed by turning or sandpapering; the mica is then cut down by starting the belly of the file at the outer end of the commutator and working toward the risers, using the groundoff end of the file as a sort of plow. The belly of the file follows in the groove cut and keeps the tool on the mica. A little practice will enable one to undercut the mica of a commutator by this means in a surprisingly short time. The groove is not deep like that cut by a hack saw and is not as troublesome in the way of collecting dirt. After the mica is undercut the commutator is again smoothed and cleaned. The writer has used this means to cure rough commutators very often and has found it an excellent expedient.

Commutators often give trouble due to excessive heating, short-circuits between the bars and grounds. In many instances such troubles are due to deterioration of the mica by oil. There is often a leakage of oil along the shaft from the bearings and the oil creeps up onto the commutator, soaks into the mica and destroys its insulating qualities. The current then leaks through from bar to bar and causes excessive heating and possibly short-circuits. Sometimes the mica rings break down, producing a ground. Special care should be exercised to keep the commutator free from oil. Where there is leakage a leather washer, held against the inner end of the bearing housing by a sheet-iron washer of slightly larger inside diameter fastened to the housing with screws, will prevent suction of oil and keep it from creeping along the shaft from the bearing.

When it is found that the mica segments have been rotted in spots, all blackened mica should be scraped or dug out with a broken hack-saw blade with the set of the teeth ground off. The void should be filled with a paste consisting of powdered mica (two parts), plaster of paris (one part) and enough shellac to make a thick paste. The copper around the patch is then heated slightly with a torch and the paste allowed to harden. This will require but a short time. The surface of the commutator is then smoothed over and the machine is ready to run. If properly applied, a patch of this kind will not come out.

The keynote to success in caring for direct-current motors is to anticipate trouble and take proper steps to prevent it before the commutators begin to deteriorate. After they once start to cutting or roughing they get worse and worse so rapidly that it is almost impossible to stop it except by turning down.

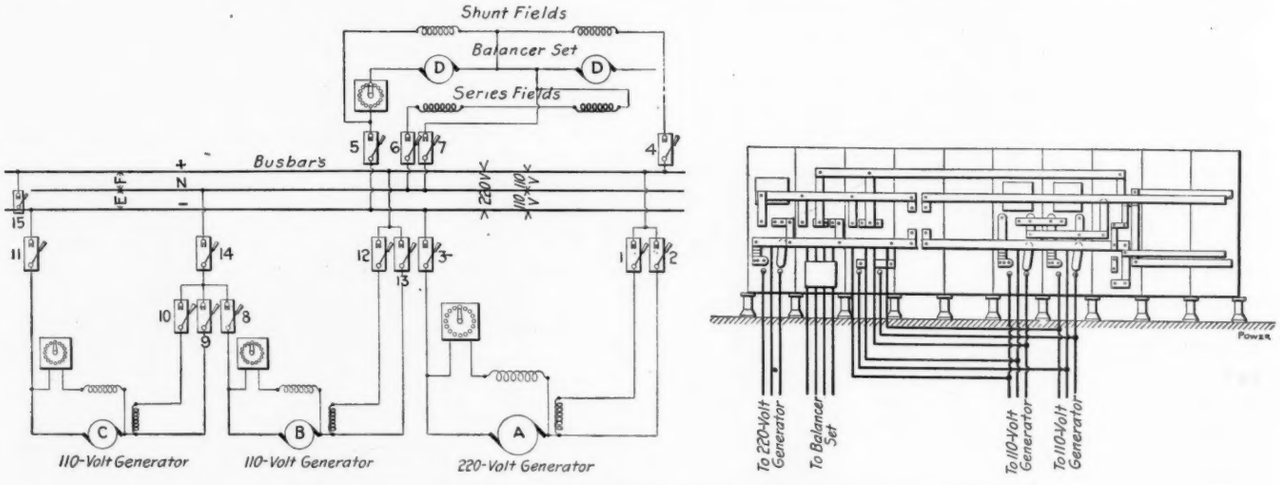


Fig. 2. Wiring Diagram and Connections at Back of Switchboard

CORRESPONDENCE

Isolated Plant Operating Costs

On page 179 of the issue of August 1 is a letter from Henry D. Jackson, discussing the item of profit on investment used in my article on Mr. Rushmore's operating costs in the issue of June 27. Mr. Jackson bases his contention, that this item of profit should not be included, on the conditions existing in a manufacturing plant. Following out his line of thought, a manufacturer would figure his selling price as being the total cost of production in the shop plus an overhead charge to cover depreciation, interest, taxes, etc., plus a further charge covering the cost of sales and profit. He would not departmentalize his manufacturing establishment, but would treat it as a complete and well balanced factory, operating within itself every individual treatment or process necessary in the complete manufacture of its product. If any of these individual processes were left out, Mr. Jackson fears that the factory would be unbalanced and not satisfactory.

The development of the large manufacturing concerns of the country in the last five to ten years does not bear out this line of argument. Ten years ago, or even more recently, the majority of the larger manufacturing plants were operated each as a unit, the total investment being lumped in one sum and the overhead charges being made the same all over the factory. This left the manager of a factory in absolute ignorance as to where the plant was making money and where it was losing it, and it gradually forced the owners to the division of their plants into departments. As a result, the management of a plant is in a position to determine absolutely which class of manufacture it is most advisable to develop, and this knowledge has been used to excellent advantage.

Referring to the question of the heating plant cited by Mr. Jackson, such a plant, or, rather, some means of heating the buildings, is necessary. The capital invested for this purpose, however, forms a portion of the capital stock of the company. If the business is successful, it must pay a dividend on this stock, and, therefore, must pay a dividend on the amount invested in the heating plant. Since the heating plant is not a producing department, this dividend must be paid by some other department. If the company, for example, is paying 7 per cent. dividends and heat can be obtained from an outside concern for a price equal to the operating cost of producing heat in the heating plant, plus the depreciation, interest, taxes, etc., plus a profit of less than 7 per cent. on the capital invested, then it would be an economy for the company to buy heat, as some portion of the proceeds from the other department which has been paying the dividend on the capital invested in the heating plant will now be available to increase the dividend rate.

I hardly see how Mr. Jackson can raise the question of whether a manufacturer must consider that he should make a profit on the cost of his buildings or the cost of his transmission apparatus. The capital invested for such purposes forms a portion of his capital stock on which he must pay dividends. If the capital invested in this way does not of itself produce these dividends, they must be produced by some other portion of the plant. There are many factors besides the question of initial expense that enter into the determination of whether a manufacturer should rent or own his buildings, such as convenience of location, layout to suit special needs of the manufacturing process, freedom to make changes and alterations of a permanent character, etc.

In the editor's comment the point is made that no certainty exists that the manufacturer could make a profit on a given amount of capital by investing it in some certain part of his business instead of in the power plant. Unless some department offered such a certainty, it is equally certain that the business would not be a paying one, and hence a manufacturer probably would not have any available capital to invest in his power plant or anywhere else. If such capital is available, it is *prima facie* evidence that there is some department which will earn a profit on such additional capital available for investment.

The editor also points out the fact that the interest on any investment put in a power plant goes on, whether the power plant be operated or not. This is one of the strongest reasons against the installation of an isolated power plant. The history of the development of all classes of business has been that the selling price of the product of any particular class of business decreases as improvements in the art increase. An isolated plant today may show a profit over the cost of power from the central station. Five years from today the central station would in all probability be in a position to supply power cheaper than the isolated plant, but the manufacturer is already saddled with a large investment in his plant which must be depreciated, and on which interest and other charges must be paid. This amount may be so large that he will not be able to avail himself of the advantages offered to the central-station plant.

A competitor starting in business under the new conditions is able to take advantage of the central-station proposition and thereby undersell his opponent who isolated his power plant five years before. The new competitor is able to extend his business more readily, with less delay, and with a smaller capital increase than the older manufacturer. In short, with an isolated plant once installed, the owner thereof is compelled in a large degree to follow out a certain line of action and is not left free to exercise his judgment in choosing the course which may be most economical for him.

R. D. De Wolf.

Rochester, N. Y.

[Mr. De Wolf's reference to our comment following Mr. Jackson's letter is not quite accurate. We did not say there was no certainty of making "*a* profit" on money invested in the manufacturer's business; we said there was no certainty that the money represented by the power-plant investment would, if invested in some other department of the plant, earn *the* profit estimated by the central-station solicitor.—Editor.]

Mr. Crane's Switchboard

In the issue of August 1, G. H. McKelway and A. L. Harvey offer some criticisms of the switchboard which I described in the issue of June 20, which lead me to explain that this board was not meant to take the place of the usual panel switchboard in a power station of such size that an attendant is always at hand and gives considerable attention to the looks and care of the board; it is suitable and much preferable, however, in small plants where no attendant is employed.

My occupation takes me into a large number of manufacturing plants and I have seen many of the slate and marble switchboards located near walls, with the space behind the board filled with all sorts of scrap and used as a general receptacle for all kinds of material. With a board of the construction I described, everything is open and no space is offered to serve as a refuse can.

Mr. McKelway misunderstood the last paragraph of my article; this was intended to mean that the price was for the installation complete without the motors; in other words, for supplying the switchboard and the wiring for the motors.

If preferred, and as undoubtedly required by the underwriters in the East, it is possible to make the cross pieces of pipe instead of hard wood (treated).

Referring to the relative costs of the two kinds of switchboard for the plant mentioned, the figure on the switchboard alone, using slate panels, was $250 and the cost of the wiring for the motors and the skeleton board described was $240.

This type of construction is being used for several other purposes and is now recommended by the larger electric companies for mounting starting compensators, oil switches and such apparatus where they used to recommend slate panels.

Duluth, Minn. J. B. Crane.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Gasifying Crude Oil

By H. A. Grine

There are practically three general methods of gasifying crude oil, namely, destructive distillation, destructive distillation and partial combustion combined, and partial combustion. In the first method the oil contained in iron or fireclay pipes or retorts is gasified by applying heat to the outside of the pipes or retorts and causing destructive distillation of the oil, or by heating up chambers by blasting and alternately making gas by discontinuing the air of the blast and spraying in oil and oil and steam. In some cases a small amount of air or steam is admitted with the oil. These methods retain the objectionable features of requiring a frequent burning out of carbon, and forming a gas composed mostly of hydrocarbons and therefore not well suited to gas engines.

The second method is a step forward. It is usually carried out in shells similar to those used in domestic gas plants or in specially designed shells or generators. It consists in injecting or distributing oil within a closed shell or generator in the presence of sufficient air to cause partial combustion of part of the oil and destructive distillation of the remainder. Usually sufficient partial combustion is permitted to maintain a temperature high enough to make the process continuous. Owing, however, to the destructive distillation and carbonization of a large part of the oil, sufficient lampblack is formed to gradually stop up the outlet pipes and generator. This difficulty has been met to some extent by burning out the generator while running on gas from a gas holder, or by providing duplicate units and changing at stated intervals. Gas made by this method still retains a relatively large percentage of hydrogen and hydrocarbon gases, and is not considered by gas-producer engineers to be as well adapted to gas engines as the gases made by coal-gas producers, which contain a higher percentage of the slow-burning carbon monoxide gas. Attempts have been made so to proportion the air as to burn up the lampblack as fast as it is formed, but none has succeeded so far, owing probably to the fact that the gases formed by destructive distillation are more readily combustible than the lampblack and take up the oxygen before the lampblack can be gasified.

The third method is the most advanced as the oil undergoes almost complete dissociation; the hydrocarbons are broken down into small percentages of methane and hydrogen and the carbon is oxidized chiefly to carbon monoxide. The proportions of carbon monoxide, methane and hydrogen in gases formed by this method are almost ideal for gas-engine work. The gas is easily ignited but has not the snappy sharp explosion so characteristic of gas containing large percentages of hydrocarbon gases and hydrogen, with little carbon monoxide.

In the past few years certain engineers have been investigating and developing the crude-oil gas producer along lines of proved practice in the gasification of bituminous coals, and there has been progress made which seems to assure the success of the crude-oil gas producer, and promises a very low-cost power-developing system for sections where oil fuels of any grade are the most readily available. A gas producer has recently been constructed for use with crude oils and in commercial tests has demonstrated its merits. A 100-horsepower plant installed about the first of this year is in daily operation 24 hours per day, furnishing gas to an engine driving an air compressor and a duplex water pump. The unit has only one gas generator, requires no rotary or other mechanical scrubber, and the amount of carbon byproduct is negligible. The operation is continuous, and the generator requires no burning out and no more attention than a boiler plant.

The system has a great advantage in the fact that it secures a greater decomposition of the hydrocarbons of the oil and forms a gas containing a larger percentage of carbon monoxide than is produced in other oil systems. An average analysis of gas made is as follows:

CO	15.0 per cent.
H_2	6.1 per cent.
CH_4	5.3 per cent.
C_nH_{2n}	1.1 per cent.
CO_2	6.7 per cent.
N_2	65.6 per cent.
O_2	0.2 per cent.

The heat value is 148.4 B.t.u. per cubic foot.

A Steam Engineer's Experience with Gas Power

By S. G. Rose

As the question of putting gas-power plants in charge of steam engineers has received considerable attention recently, the following remarks may be of interest to those confronted by that problem:

I am operating a gas-power plant consisting of two engines and two suction producers, with the usual auxiliaries, such as a small engine for pumping compressed air to start, pumps, etc. Before taking charge of this plant I had been operating steam engines and boilers. I started in as a boy working in a locomotive roundhouse and went to firing as soon as I was old enough. Eventually I got to be an engineer. I started in this country as a stationary fireman and a little later became an engineer. When my employers enlarged their plant and put in gas engines I was selected to run them. I took a liking to the gas engine from the start and put in a good many hours studying it and the principles on which it works. Except for a few blunders on the start I have not had any trouble with the engines; they have not had a 5-minute compulsory shutdown so far this year.

I do not see any reason why any steam engineer worthy of the name could not do exactly what I have. The gas engine and producer only require a little evening study and a little closer attention than a steam plant when running. There have been some good articles published in this paper by Cecil Poole on the suction-gas producer and I think it will pay steam engineers to study them.

Referring to the amount of attention required by a gas-power plant, I fail to see how C. O. Hamilton* could expect a man to run a 200-horsepower suction-gas plant with only three hours' attention per day, and I think it would be better for anyone who has the welfare of the gas engine at heart not to make such assertions. It causes a lot of trouble between owners and engineers when the owners have been led to believe that such economy in labor is possible with the suction-gas producer and engine. I find that the more attention I give my plant, within reasonable limits, the better are the results.

In a plant of 200 horsepower, on full load, I should expect about 2500 pounds

*"Steam Engineers for Gas Power Plants"; May 16 issue of Power.

of pea coal per day and if there is not a storage bin overhead it would have to be put in scuttles holding about 45 pounds; that means about 55 scuttles per day. That alone would occupy about 1½ hours of a man's time. Sometimes the coal has to be screened and it may have to be wheeled in from a shed; these operations, of course, add to the time required. Then, again, some producers require poking before starting and cleaning out at noon and night. If they are without shaking grates, like these I am operating, this takes up some time and when they are running they also require a certain amount of attention, such as poking the fire over the bars occasionally, poking down from the top of the generator and keeping an eye on the water going to the vaporizer and the scrubber. Then there are ashes to be removed and the producer room to be kept clean; the fine ash from the generators makes quite a mess over everything. The excelsior or sawdust and coke in the scrubbers should be changed occasionally and the gas passages must be kept free from dust and other obstructions; the blowoff valve gets dirty very quickly and if there are any gate or other valves they should be taken apart occasionally or the operator will find them stuck when he wants to use them. Finally, the producers should be cleaned out entirely at intervals of one to three months, according to local conditions.

So far, only the producer end has been considered. Coming to the engine equipment, I find that it does not pay to go very far away from the engine room. I would rather leave a steam engine running alone than a producer gas engine; because it is impossible to get the same quality of gas always and if an engine should backfire or preignite someone should be on hand to remedy the trouble.

Gas-engine bearings and lubrication require far more attention than those of steam engines and it pays to take a look at the lubricators pretty often. A hot bearing on a 200-horsepower gas engine entails more trouble than one on a steam engine of the same output because the bearings are much heavier. The valves should be taken out quite frequently, as producer gas is rather hard on them, and it takes quite a bit of time and energy to take out and grind a water-cooled balanced exhaust valve; the smaller valves, such as gas and mixing valves, should be cleaned every week; the engine room should be kept clean and the brasswork, which soon gets tarnished, needs occasional polishing; besides all this, there is a certain amount of petty routine work which must be done around a plant.

In my plant I have to look after three large clutches, a heating boiler, a 775-kilowatt generator and two motors and pumps and it keeps me and a helper busy regularly, with an occasional Sunday in addition.

Of course, the amount of attention required depends greatly on the equipment, but I think that if one man ran a plant of 100 to 150 horsepower he would be doing well and that it would be worth at least his wages to his employer to have the man right at hand to prevent avoidable stoppages and accidents to the equipment, leaving out of consideration the advantage of not taking his mind off his plant by having him do other work.

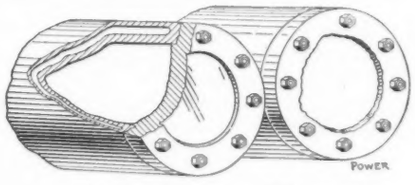
A Disastrous Dose of Water

By M. W. Utz

The accompanying sketch illustrates the damage to a two-cylinder duplex horizontal gas engine of about 85 horsepower, which occurred in a small electric-light plant and was caused by very unusual circumstances.

The air-inlet pipe to the engine runs along under the floor of the room to the outside of the building and takes air from a small concrete pit under the steps to the building.

The city water works is combined with this plant, and the water is taken from deep wells by an air lift and discharged into a large cistern just outside the plant, whence it is pumped



Damage Done by Water

into the mains by reciprocating steam pumps. The engineer allowed the water to get so high in this cistern that it overflowed, flooding the pit where the gas engine takes air, and causing the engine to take water instead of air; the cylinders filled with water, which wrecked them as here indicated.

One cylinder head was blown out, breaking along a circle just inside the studbolts, and the other head broke about halfway across and tore out part of the cylinder barrel. All the studs were "started," some were sheared off, and the threads were stripped off some. The cylinder on the left had to be replaced by a new one, of course.

The accident happened just as the motor load went off at noon, leaving the engine running almost idle. No one was hurt, but the engineer had just walked past the engine and over to the opposite side of the room to shut off the air compressor, missing being caught in the wreck by a few seconds.

Of course, accidents will happen in almost any power plant, but isn't it poor judgment to have a gas engine take air from an underground pit?

Points in the Operation of Suction Producer Plants

By N. E. Woolman

The readers of the Gas Power Department no doubt have experienced trouble in starting suction gas-producer engines and have said things that would not look very well in print, in the end, however, finding a good reason for the trouble.

One of the most common troubles is water in the gas, which short-circuits the igniter. The cause is due, principally, to blowing hot gas through a wet scrubber, but it might be caused by the hot gas passing over the water in the seal. It is very misleading at times, because the igniter will test clear when the engine is standing, but the incoming charge will carry enough moisture to short-circuit it upon starting.

In a great many cases trouble will be experienced with the engine flooding with gas when the air is taken through a long pipe from the outside of the building; this is quite common with an extremely hot fire, because the draft in the producer "pulls" the gas over more rapidly than the corresponding volume of air can be sucked through the long pipe. If the engine has to depend upon only one or two revolutions to take its charge and start, some difficulty will be experienced unless the air pipe is disconnected. If the engine is equipped with an automatic air starter, this trouble will seldom occur if the compressed-air tanks have capacity enough to keep the engine going long enough to start the column of air in the supply pipe.

It often occurs that trouble will be had from too hot a fire or abnormally rich gas if there is appreciable resistance in the air intake; with a hot fire there is very little resistance to the gas flow. A graduated dial on the gas valve is handy in such cases; with a little practice one can adjust it and never lose a start.

A great deal can be gained in economy by having the fire as nearly as possible at the right temperature at the start. If the fire is too hot at the start it will be impracticable to feed enough steam to it to cool it down for several hours on account of preignition and back firing at the engine, and during that time hard clinkers will form. The extremely hot part of the fuel bed at that time will probably not exceed 18 inches in depth and will be sticky and offer a good deal of resistance to the air passing through. The path of least resistance is next to the firebrick, where the air and steam will harden the clinkers that have already formed.

It is a known fact that it takes considerable blowing to vary the fire beyond a certain depth. If an engine were started with the fire not sufficiently hot, the

steam would have to be held off until the engine had "blown" it hot by suction; then when the steam was turned on the excessive draft from the engine would pull holes through the fire and weaken the gas to the extent that it would be difficult to carry the load. In that case it would take several hours to get the fire in good condition and during that time there would be an appreciable waste of fuel and power.

It is important to the economical and successful operation of a suction gas plant to admit steam to the fire immediately after starting, because if the steam is withheld, the engine will "pull" the fire to an excessive heat and waste the fuel. If the steam is not carefully regulated to the fire in that condition, there will be a good deal of trouble in the way of back firing and premature ignition at the engine, especially if the engine is well loaded and carrying full compression; the chances are that the trouble will continue during the run.

A superimposed vaporizer, or one that utilizes the heat from the hot gas, is not very satisfactory in most cases, more especially when starting up, because it takes too long to get steam; the steam has a tendency to work the fire upward and the nearer it is to the vaporizer the more steam will be produced, regardless of the load. It is not at all easy to automatically regulate the water and steam to the varying temperature and load conditions, but the most successful form of vaporizer is one that automatically regulates the supply of water to the varying load.

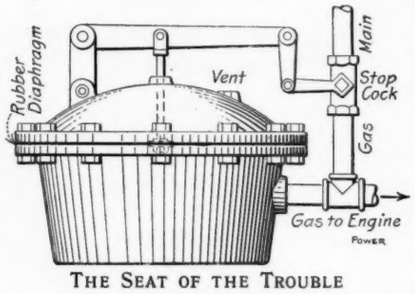
One of the chief causes for so many failures in suction gas-engine installations is carrying too high compression; with very high compression an engine will not stand the varying quality of suction gas. There are large engines carrying from 170 to 200 pounds compression pressure and giving good results. but it is owing principally to the scavenging effect due to proper timing of the valves. Judging from all reports, an engine using about 140 pounds compression gives the best all-round results, in view of the fact that it takes a larger bore and stroke to produce the same horsepower.

Why the Gas Supply Failed

By H. H. Daniel

A pumper from a nearby oil lease recently called on me to examine his engine, as he and his son had been "kicking" it all day and were unable to get any response. This engine was a 15-horsepower two-stroke cycle machine supplied through a gas regulator which had a diaphragm across the center; attached to this was a plunger which extended through the top and was linked up to a stop cock in the main line, as shown in the sketch. When the gas pressure was above normal, the diaphragm pushed up the plunger and thereby shut off the supply of gas, and *vice versa.*

Now one thing I always like to know, before doing much to a gas engine, is whether I have got the wherewithal to make her go if she is in shape otherwise. So the first thing I did in this case was to find the regulator, push down on the plunger, and—the trouble was located. The plunger was at its topmost position with the stop cock closed, and the link levers were stuck tight. I put some oil on the joints, worked the plunger up and down a few



The Seat of the Trouble

times, turned on the gas, put my "strong right foot" to the flywheel and presto! the engine ran perfectly. What the pumper said was unfit for publication.

This engine had been shut down for a day and the gas pressure came on stronger than usual and forced the levers of the regulator up a little higher than they had ever been before, to a position where the pivots were not entirely free, and they stuck in that position.

Decarbonizing Internal-Combustion Engines

Consul Augustus E. Ingram, of Bradford, Eng., reports a British invention of interest to users of automobiles and motor cycles which has recently been brought out for the purpose of removing carbon deposits from the cylinders of internal-combustion engines. The amount of carbon deposit which adheres to the cylinder walls, piston heads and valves is considerable, particularly in air-cooled engines. With this invention it is not necessary to dismantle the engine or disturb any of the connections, and it is claimed that the decarbonizing is done quickly at trifling expense. The apparatus consists of a cylinder of pure oxygen, to which is fitted a pressure-reducing valve with a flexible tube and blowpipe connected, and is started by a small petrol hand lamp with a long nozzle and wick. The process, after the valve caps have been removed, consists of inserting the oxygen blowpipe and the lamp nozzle through the openings into the cylinder head and allowing the flame to impinge on the carbon, which immediately becomes incandescent and comes away in the form of light sparks. It is considered advantageous to warm up the engine prior to commencing operations, this having a tendency to soften the carbon slightly, making removal easier.

LETTER

Lightening Pistons Improves Flexibility and Acceleration

The engine on a pleasure omnibus suffered from lack of "life" and took a long time to accelerate, although in other respects, such as steady pulling and power, it was all right. Everything was tried, from retiming the valves to replacing the carbureter with other types for trial, but the engine did not show any improvement at all.

Finally the maker's man was sent for and after going over everything again he took the pistons out, chucked them in a lathe and took a fairly deep cut around the inside of the skirts, below the gudgeon-pin bosses. When he had removed some metal from each piston, he weighed them and then turned three of them down to the exact weight of the lightest. They were then replaced in the engine, which showed at once a remarkable improvement, although it was still rather slow in accelerating. However, it was not considered advisable to remove any more metal, so the engine was left at that.

An alternative method would have been to drill holes in the skirts of the pistons below the gudgeon pins, but this might have weakened the pistons unduly.

John S. Leese.

Manchester, Eng.

Brown, Boveri & Co., of Baden, Switzerland, have taken out patents on that type of turbine which comprises an impulse section, followed by several reaction sections. It is customary in such turbines to make the cross-sectional area of the reaction sections adequate for the flow of steam when all of the impulse nozzles are open. Under light loads when a small amount of steam is flowing the expansion is excessive, resulting in an impairment of the efficiency. The new turbine is arranged so that a reaction section is cut out simultaneously with the closing of each of the high-pressure nozzles.

Trouble is sometimes experienced in making asbestos covering stick to pipes and cylinder heads. When putting on such a covering, first coat the surface with silicate of soda, sometimes called liquid glass, and before it has time to dry apply dry asbestos as thickly as possible by handfuls. The silicate will hold enough of the asbestos to serve as an anchor for the following coats to be applied in the same way.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Approximate Heat Value of Coal

Some of the readers of POWER may be interested in a method used in a small light and power plant for finding the approximate heat value of the coal used. A daily log was kept in which was recorded the steam pressure, steam temperature, vacuum, etc., and from this log calculations were made as to the coal burned per kilowatt-hour, heat value of the coal, etc.

Nine tons of coal were used per day, and on an average 8.5 pounds of water were evaporated for each pound of coal burned. Before the feed water entered the boiler its temperature was raised to 200 degrees Fahrenheit by means of a feed-water heater.

From the daily log the average steam pressure was found to be about 150 pounds gage and the average steam temperature was about 450 degrees, showing that the steam was superheated.

Using Peabody's steam tables the temperature of saturated steam at a pressure of 150 pounds gage, or 165 pounds absolute, is 365.09 degrees, showing that the steam was superheated 84.91 degrees.

Since the entering feed water is 200 degrees and the temperature of saturated steam corresponding to a pressure of 165 pounds absolute is 365.88 degrees, then the number of heat units required to raise each pound of water through the required temperature range is

$$365.09 - 200 = 165.09 \text{ } B.t.u.$$

The amount of heat required to convert each pound of water at this temperature into steam at the same temperature is found from the steam tables to be 856.8 B.t.u. Therefore the heat required to raise one pound of water from 200 to 365.09 degrees and to convert it into steam at this temperature is

$$165.09 + 856.8 = 1021.89 \text{ } B.t.u.$$

Since the steam is superheated 84.91 degrees, the heat required to superheat this amount must be added to the above amount. The specific heat of superheated steam may be taken as 0.48; therefore, the heat required to superheat each pound of steam 84.91 degrees will be

$$84.91 \times 0.48 = 40.75 \text{ } B.t.u.$$

The total heat units required for each pound of water evaporated and superheated will be

$$1021.89 + 40.75 = 1062.64 \text{ } B.t.u.$$

As 8.5 pounds of water are evaporated per pound of coal the number of heat units that are utilized by the boiler per pound of coal are

$$1062.64 \times 8.5 = 9032.44 \text{ } B.t.u.$$

This would be the heat value of the coal per pound if the boiler had 100 per cent. efficiency which, of course, in practice it has not. The efficiency of the particular boiler in question was about 65 per cent., therefore, the actual heat value of the coal per pound would be

$$9032.44 \div 0.65 = 13{,}900 \text{ } B.t.u.$$

nearly.

This method of finding the heat value of coal is, of course, only approximate, since it depends on the efficiency of the boiler, but comparison of different fuels under similar conditions can be made very accurately and in practice this method is often used.

T. W. HOLLOWAY.

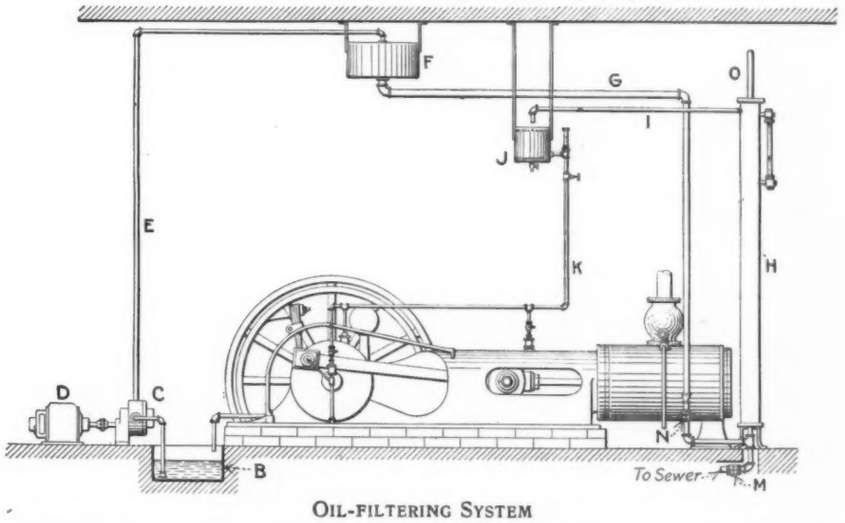
Scranton, Penn.

Oil Filtering System

A simple oiling arrangement that I have used for over two years is shown in the accompanying illustration. A hole was dug below the engine large enough to hold a 2 and 2 by 4-foot tank *B* which was to receive all oil drips from the engine. Then I set up a ¼-horsepower motor *D* and a small pump *C* to pump the oil out of this tank and get it into a tank *F* of the same size, placed as near the ceiling as possible. A 2-inch pipe *G* was connected to the bottom of this tank and ran down to within a few feet of the floor where it was reduced to 1 inch and a 1-inch valve *N* connected in the pipe. This pipe entered the bottom of an upright 6-inch pipe *H* that was 10 feet high (the higher the better). A 1-inch pipe and valve *M* is used for a drain to the sewer.

The oil and water are pumped from the tank *B* up through the pipe *E* into the tank *F*, and flow through the pipe *G* to the bottom of the standpipe *H*, which is filled with water to about 2 feet from the top. The oil rises through the water and after filtering runs out near the top through the pipe *I* into a smaller tank *J* and then flows to the oil cups on the engines through the pipe *K*. The pipe *I* must be about 12 inches below the bottom of the tank *F* or the oil will not rise high enough in the pipe *H* to feed into the tank *J*.

The tank *J* and standpipe *H* are each fitted with a gage glass to show the position of the oil. Water should show in the bottom of the glass in the standpipe *H*. If it gets too high the valve *N* should be closed and the valve *M* opened a few seconds. This will let the dirt and sediment run to the sewer and keep the water clean in the standpipe *H*, so that the oil will filter freely.



OIL-FILTERING SYSTEM

The pipe *O*, on top of the standpipe *H*, is for a vent and also to keep the standpipe *H* from overflowing. The sys-

tem holds about one barrel of oil and feeds two engines with a steady stream on the bearings. Once a month the tanks *B* and *J* are cleaned; otherwise the system does not require any attention. I plan to keep the valve *N* open just enough to feed oil into the tank *J* slightly faster than the engines use it. By looking at the feeds and gage glasses once an hour, trouble is avoided. I ran the standpipe *H* up beside the exhaust pipe, as the oil filters better when kept warm. One barrel of oil is used about every 10 days. There are no screens or waste to clog up and the dirtiest oil can be filtered.

The tanks, motor and pump were found in a corner so that the system cost but a few fittings.

P. B. HARTFORD.

New York City.

Hot Bearings

Regarding cooling hot bearings, I have used water, graphite and sulphur with and without oil or grease and have had better success with sulphur in cooling very hot bearings than with anything else.

I was oiling on a steamboat once where the crank pins, wristpins and main bearings were all lubricated with hand-compression grease cups. One of the crank pins got so hot at one time that the cooling water in striking it sent up clouds of steam. When I came on watch the engines were running at reduced speed in an endeavor to cool the pin.

The chief suggested stopping to loosen up the brasses, but the weather was rough and we were on a dangerous coast. I got some sulphur and mixed it with the grease and fed it through the grease cup to the bearing. In less than half an hour we were running full speed again.

If a bearing is very hot and sulphur can be fed into it, either in the oil or through a grease cup, it will surely prevent seizing, as it will melt at a much lower temperature than the babbitt of the bearing and will form a film around the bearing and reduce the friction.

Graphite will pack in the bearing and unless it can be forced out it may prevent oil from getting to the bearing. Cold water is very apt to make the bearing shrink and seize the shaft. If water is the only cooling agent at hand, it should not be applied directly to the journal boxes but to the shaft or exposed part of the bearing; these parts should be cooled before cooling the box. This will cause the shaft or pin to shrink slightly and will give the oil or grease a chance to get in around the bearing. Then force a little graphite or sulphur in with the lubricant and the engine need not be stopped.

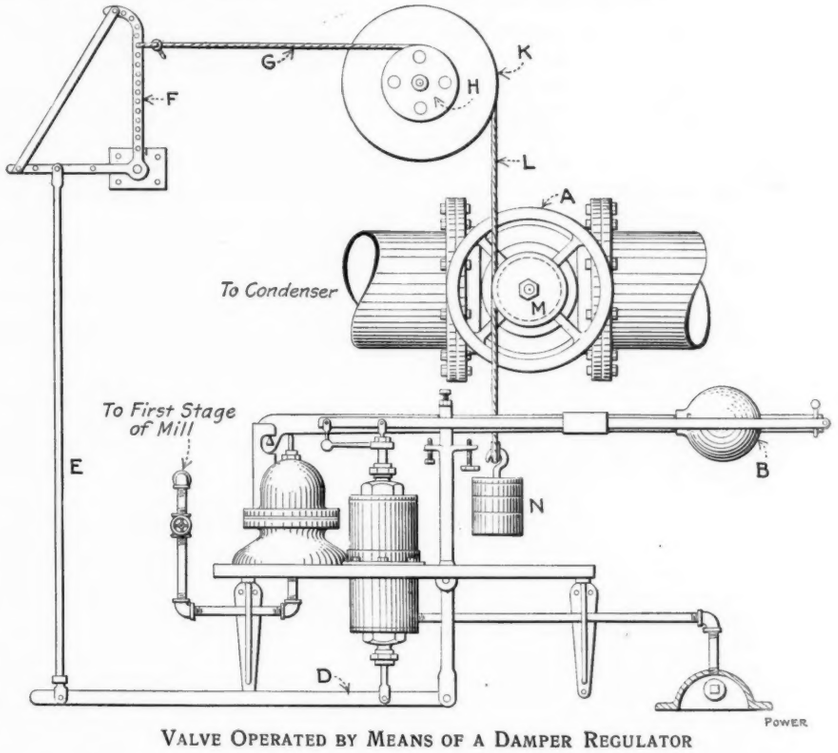
A. A. BLANCHARD.

Oak Harbor, O.

Automatic Control of Circulating Water

When the 500-kilowatt steam turbine was installed it was arranged to drive the circulating pump by an electric motor. Aside from the questions of economy involved, other serious faults were soon revealed, not the least of which was the motor's subservience to the law of synchronism with its source of power. This resulted in the delivery of the least amount of water by the circulating pump when the most was needed. This peculiarity, however, had been anticipated and partially allowed for by the installation of a pump which was capable of delivering sufficient cooling water while the turbine operated at overload speeds.

But as the turbine was subject to very variable loads, the pump at periods of light load delivered considerably more water than was required; which resulted not only in the useless expenditure of power but also in the loss of heat units in the condensate, which at this station is returned into the boilers.



VALVE OPERATED BY MEANS OF A DAMPER REGULATOR

The pressure in the first stage of the machine varies according to the drag on the turbine and the idea was conceived of communicating the pressure of this first stage to the pressure chamber of an old damper regulator, which by means of suitable levers and pulleys was made to control the regulating valve on the circulating-water line between the pump and the condenser. The manner in which this was accomplished is shown in the accompanying illustration.

The regulating valve *A* is opened by hand enough to allow the passage of sufficient cooling water to maintain a good vacuum while the load on the turbine creates a pressure of not over 20 pounds in the first stage. When this is exceeded, the pressure will overcome the purchase and gravity of the balancing weight *B* on the long lever of the regulator; and the regulating valve *A* is opened by means of the lever *D*, rod *E*, arm *F*, rope *G*, sheaves *H* and *K*, rope *L*, sheave *M* and weights *N*.

The amount of regulation is controllable by shifting the hook of the rope *G* on the upright piece of the arm *F*. As there is often a vacuum in the first stage of the turbine, it is necessary to guard against undue breathing of the diaphragm of the regulator by fitting a perforated plate to support it.

C. HUGHES.

Saxonville, Mass.

Dilapidated Boiler Conditions

The boiler battery in a certain plant consisted of two 72-inch return-tubular boilers in one setting.

Boiler No. 1 was equipped with a low-water alarm, which had been installed by drilling a hole through the shell between the manhole and the steam dome. This pipe ran down to within ¾ inch of the top row of tubes, and before the whistle blew the water would be below the safety point.

This side of the setting had settled 2½ inches, so that when one gage of water showed on No. 1 boiler, it was out of sight in the water glass of No. 2 boiler.

Both boilers were connected with a cross dome, and fitted with a ball and lever safety valve which was set so close to the roof, which had also settled, that one of the rafters rested on the lever; 100 pounds gage pressure was carried.

When I went into No. 1 boiler I found two braces broken on the back end, which had a bulge of 1 inch.

J. A. McQUEEN.

Cheboygan, Mich.

Required Nerve

In a certain power plant there were 10 steam engines working in pairs with one flywheel, each set driving a pair of generators with a load of from 500 to 800 amperes.

One morning the switchboard tender called for another machine, so my partner and I got a pair of engines ready but there was not enough load for the two machines. I opened my throttle wide, which required about 12 or 14 turns, while my partner opened up the other throttle two or three turns. While waiting for the load to come on I saw the rope drive standing. The switchboard tender cut out the machine suddenly and the engines began to run away with full steam pressure and no load.

My partner had no trouble in shutting down his engine, but I did not take time to close the throttle. Instead I caught hold of the blocks and kept them up so that the hooks would not catch on and open the steam valves. I held on until the engineer closed the throttle—which seemed to me like a lifetime—standing in front of the swiftly revolving wheel while the rope was tearing the wooden floor and sending pieces of boards over my head and at my feet. If I had stopped to close the throttle the engine would have gained too much headway and an exploded flywheel would have resulted.

P. J. McENANEY.

Chicago, Ill.

Receiver Condensation

Several days ago I visited a friend who is operating an 18 and 38 by 30-inch vertical cross-compound engine, which runs at a speed of 155 revolutions per minute with 150 pounds gage pressure and carries about 400 kilowatts. He called my attention to a ½-inch stream of water which was escaping from an automatic valve from the receiver. He said it flowed continually while the engine was running and that he was at a loss to know why there was so much condensation.

The receiver is well covered and there are live-steam pipe coils in it to act as a superheater.

At present a portion of the main steam line is not covered, but there are separators that would surely handle all the condensation before it reached the high-pressure cylinder.

Can any reader who has had experience with compound engines give a reason for so much condensation?

WILLIAM H. SWOPE.

Tiffin, O.

Scale in Suction Pipe

At the plant where I am employed a part of the equipment consists of an open feed-water heater made similar to that shown in the sketch. Two 7½ and 5 by 6-inch duplex feed-water pumps are used and the compound is fed into the suction between the heater and the pumps.

When first put in operation the pumps handled the water at a temperature of 204 degrees Fahrenheit without giving any trouble. Two years ago it was found necessary to put in a ¼-inch cold-water connection, not shown in the sketch, so that when one of the pumps started bucking, it was given a little cold water until it worked smoothly.

Matters, however, kept getting worse until it was necessary to keep the ¼-inch valve open all the time with the water in the heater at 204 degrees Fahrenheit. I put new valves in both feed-water pumps and repacked the water ends all of which seemed to make them buck worse than ever.

Then I removed one side of the heater, cleaned everything out and put in new filtering material, but it did no good. Finally I got a chance to shut down and got busy on the heater connections; although the water was carried as high in the heater as it would stand, I had decided that there was not enough head for the temperature.

First the plug in the line was removed and I expected to see it full of scale, but it was as free as on the day it was put in. I began to feel that I was on the wrong track, but kept at it and started on the other end. I then found that the 4-inch suction pipe was almost full of scale, as shown by the dotted lines in the accompanying illustration. From the compound connections to the heater there was only a 1¼ inch opening. The pumps now handle the water at 206 degrees without any trouble. This would have been the case at all times had the compound been fed into the nipple close to the heater.

B. S. HARTLEY.

Tipton, Cal.

Firing Boilers

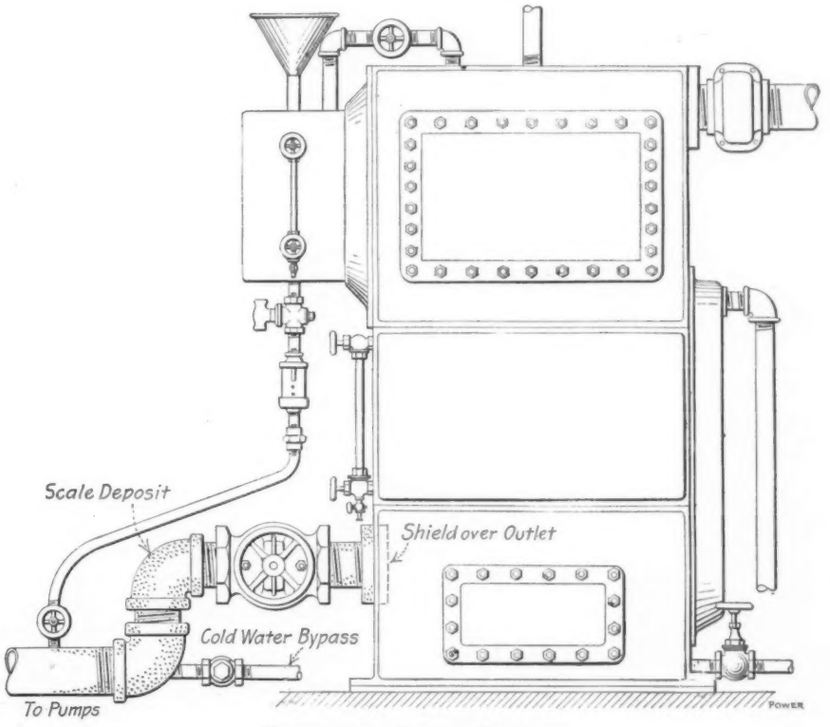
A fireman's work, if properly performed, requires considerable skill and science. He must change his method of firing every time the quality of the coal varies and even batches of coal taken from the same lot have to be handled differently. A fireman must not only handle the fires according to the quality of the coal, but to suit the boilers as well.

An engineer can tell a fireman the best way to manage the fires, but it is up to the fireman to find out for himself the better way.

Take all the advice that is given, sift it down until the meat is found, then use the best of it.

W. BROWN.

Waterford, Conn.



HEATER AND SCALED SUCTION

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Massachusetts License Laws and Examiners

In the August 1 issue, Mr. Levy mentions a number of questions propounded to applicants for examination which may be true and again may not be; that is, unless the information was obtained first-hand. It is a trait of human nature when failing in a certain desired aim to find plausible excuses and in the case of failure to pass an examination, quite often the excuse given is the unreasonable questions asked.

Mr. Levy speaks about the retubing of a Babcock & Wilcox boiler and that no one ever heard of a third-class engineer retubing such a boiler; also that he worked in eight different plants, some of them large and uptodate, and none of them possessed a tube expander. All the power stations of our local street-railway service, as well as electric-lighting service, are provided with expanders, and personally some years ago, while carrying a third-class license, I very often cut out and put in new tubes; of course, under the supervision of the chief engineer.

As to the statement that the examination fee should be refunded if the applicant is rejected, this would mean that some men would be up for examination every 90 days or as soon as the law would allow them after the previous examination.

I have been present a number of times at the examinations and have failed to see where really unreasonable questions were asked. It is true that examinations are stricter than they have been in previous years, and some may believe them a little too strict, but as a whole, the examiners who have risen from the ranks are fair-minded and endeavor to do justice. It is not just to say that there is a conspiracy against the engineers and firemen and it is equally unjust to insinuate that first-class engineers have conspired to keep their assistants down because they fear a natural competition for the higher-priced jobs.

Referring to personal experience, the plant where I am employed requires a first assistant with at least a second-class license providing the chief engineer is on the premises all the time, or otherwise a first-class license is required of the assistant. During my seven years' connection with this plant, a number of men have procured first-class licenses who came to the plant with a second- or third-class license. One among them is now a State inspector, another has gone to a larger job and a third is still with us.

I do not believe that the questions asked applicants for a second- or even a third-class license will make any of our uptodate chief engineers gaze dumfounded, as Mr. Levy states. He also mentions House bill 310, which was before the last session of the Legislature, with the comment that he had a bouquet handed to him in the shape of this bill, mentioning that he was already to smile but found that the right of appeal had been taken away from him.

Having had considerable to do with this bill, I may be able to point out a few incidents which may enable Mr. Levy to understand the matter more clearly. House bill 310 was drawn by a number of men representing various bodies and was presented to the Legislature. There were a number of hearings given by the mercantile committee of the Legislature which were generally only attended by the committee interested, although the widest publicity was given as to the date of these hearings. When the various committees, representing educational as well as labor organizations in the engineers' field, found that there was something in the bill which they did not quite agree upon, these various committees met at the State house in Boston a number of times, some sessions lasting until midnight or later, endeavoring to the best of their ability to bring out a bill which would serve all interests as much as possible. The result was a perfected bill which was called Senate bill 470 and which was returned to the mercantile committee. This committee gave numerous hearings, generally noted for the absence of many men who were but too ready to immediately criticize the actions of their committees.

Mr. Levy also cites the Pittsfield disaster, saying that as long as the present situation prevails, such disasters will continue. One reason why a board of three examiners was specified in the new law to examine men for the higher grade of licenses was to eliminate the human equation as much as possible by holding three men rather than one responsible for the granting or not granting of a license. And while there is no appeal from such an examination the applicant has the right to again apply after 90 days. This will also tend to eliminate the so-called personal trick or catch questions which so many talk about, but personally I have no knowledge of them.

I would like to add that there is no better way of getting acquainted with the Massachusetts license law and its workings than to occasionally visit room 3 of the State house, where this department is located, and many prejudices will disappear when coming in personal contact with the men composing the department, and especially so if present at a few examinations.

ALBERT S. SMITH.

Boston, Mass.

In the August 1 issue, J. A. Levy makes a protest against what he terms "the unjust system existing in Massachusetts." His view of the present system, however, is probably not held by more than a small percentage of the engineers in that State.

If only a certain set of the "cut-and-dried" questions were used in examinations, it would be an easy matter for any person desiring a license to memorize the answers and be able to answer them satisfactorily. The use of unexpected and so-called "catch questions" is the examiner's only means of finding whether a man is really well informed and capable, or has only been coached and crammed for the purpose of securing a license. Just as we may use a yardstick to find the dimensions of a much smaller object, so the examiner makes use of questions which he may not expect to have fully answered, but which will help him to determine the true measure of the man.

It should be remembered that from the results of an examination the examiner must judge not only of the knowledge and experience of the applicant, but of the latter's resourcefulness and ability to meet an emergency—qualities that should be possessed by every engineer.

It is probable that the examiner was justified in refusing to grant a second-class license to the engineer mentioned, although he had run a plant for seven years. Experience is a good teacher, but

even that cannot make a capable engineer out of some men. If this man had been certain as to his ability, why did he not bring his case before the Board of Appeals? Of course, occasionally some engineer feels that he should have been granted the license which was refused, but generally he studies and works the harder and tries again.

I once heard an examiner ask an applicant for a second-class license how he would proceed to lower the pressure at which a pop safety valve would blow, and the reply was as follows: "I would screw down on the spring." Another was asked to explain the working of an injector and replied, "It works by suction," which was all the answer he could give. A second-class license gives the holder the right to operate first-class plants and in many places they are practically in charge for days at a time.

The idea that men are required to take several examinations before the license is granted that the examiner may obtain a fee for each examination does not seem plausible, when it is remembered that they are paid fixed salaries and that all fees so obtained go to the State. A small fee is no doubt necessary to prevent waste of time by those who might come needlessly were no fee charged. When compared with the $5 to $10 per year charged in some places, the charge of one dollar per examination seems reasonable.

Mr. Levy's suggestion that the first-class engineers and the State examiners were in league to keep down the other engineers would be amusing were it not for the slur it seeks to cast upon a large number of conscientious and responsible men. However, as there is little danger of its being taken seriously by anyone, further comment seems unnecessary.

That it is easier to look for flaws in the present law than to devise a better one, is shown by the fact that other States are using the Massachusetts law as a model.

If the standard of examinations be lowered it will lower the value of every engineer's license, whether in force at the time or given later.

ROY W. LYMAN.

Ware, Mass.

If such a condition exists as is pictured by Mr. Levy in the August 1 issue, it is high time that the authorities were compelled to look into the matter as it is conspiracy pure and simple.

I have often questioned why an engineer should be obliged to pay a tax on his method of earning a livelihood. Is he a nuisance? Is his business objectionable or detrimental to the general public? Why should he pay this tax any more than the blacksmith or the tinker? The wages compare favorably with those of these callings.

I firmly believe that a man in charge of or responsible for a steam boiler should be examined as to his fitness for the position. I do not believe, however, that he should be examined on subjects entirely foreign to the boiler. If he is competent to handle the steam-making end of the plant, his duty to the public is accomplished. If he cannot make good in the engine room, it is up to his employer. And last but not least, let the examination fee come out of the public treasury and not out of the wages of a man who has to struggle to make both ends meet. I have held a Massachusetts license for years, but I could not pass the present examination if required to do so.

SHERBORN FOSTER.

Bennington, N. H.

Referring to J. A. Levy's protest against the tendency of the present-day license examinations running to technicalities and the grading of engineers, I think that while the questions should as far as possible avoid theory, still they ought to be very thorough as far as the applicant's knowledge of boilers, the expansive power of steam and his knowledge of combustion, furnaces and their handling is concerned. For instance, he should know the safe working percentage of the various kinds of joints, the bursting and working pressure, capacity of boilers, staying of flat surfaces and the proper tensile strength of plates and shearing strength of rivets; in fact, he should be able to decide for himself whether the boiler is safe for the pressure carried, and if not, he should have the backbone to refuse to operate it and be backed up by the examining engineers. The dangers of scale and inside and outside corrosion, their cause and prevention, the proper placing of the accessories to the boilers, feed pumps, injectors, etc., should also be covered as the boiler plant is really the place where the greatest danger lies and should be more thoroughly gone into than any other part of the plant.

The ordinary operation of engines and dynamos could then be taken up in order to ascertain if the applicant is familiar with the dangers incident to handling them, but as those dangers are more or less local I do not think it necessary to go into the design of the various machines on the market today. I have always looked on my license as a guarantee to the man employing me that I was capable of directing and advising repairs or changes to be made in the present plant or the installation of new units. I have met a good many engineers who as soon as they got a license dropped all further study. This is altogether wrong. An engineer to be worthy of the name must read continually; besides going over the old subjects he must buy books and seek to find out the cause of all the effects he sees himself and hears about; otherwise we are not worth a laborer's wages if we only know how high to carry water and when to blow the whistle.

Knowledge together with organization will advance us to the position we ought to occupy in the industrial world. Therefore I say, let the examination test a man's knowledge in all essentials to safety which cannot be done without in a measure testing his efficiency. As to the grading of engineers, I agree with Mr. Levy that one grade is sufficient; then let the man advance himself. I think Chicago has about as good a license law as any city. The board is composed of practical men, and while in the past there may have been some slight irregularities, still the results have been excellent. My examination, as I remember it, was entirely unobjectionable and yet sufficiently comprehensive. I know I put in eight or nine hours of hard writing and I have heard some say they took two days to complete it. Judging from the personnel of the present board, I think the past will be improved upon by their work. Here we have only one grade, and a man must do two years' firing before he can come up for examination.

If we want to increase the respect for our calling we must have the courage of our convictions, even to falling under the displeasure of our employer if necessary when ordered to do things we know are bad engineering.

It is no excuse to say, "the boss owns the plant." We are in charge and responsible for it.

WILLIAM CHADDICK.

Chicago, Ill.

Sizes of Belts

In the August 8 issue Mr. Mosher gives a formula for determining the size of belt for transmitting a certain load. In this formula he recommends approximately 60 pounds as L the working load per inch of width of a single belt. The usually accepted effective pull is about 33 pounds per inch of width, making a belt 1 inch in width, traveling at 1000 feet per minute, capable of transmitting 1 horsepower, although many people have increased this pull to a point at which 1 horsepower will be transmitted by a 1-inch belt running at 600 feet per minute. The high limit of 55 pounds per inch of width may be well within the capacity for the belt as a transmitting medium so far as its strength for direct tension is concerned, but any such pull as this will result in considerable stretching. Besides increased attention, this will result in the use of much narrower pulleys; also, although the first cost is less, the maintenance expense is greater.

F. W. Taylor, in his study of this situation, recommends an effective pull of 25 pounds per inch of width for a double

belt, and while this seems very low, it doubtless results in an exceedingly low maintenance cost, and the total resultant cost is correspondingly low.

The difficulty in many factories is that the belt pulls are far too great for satisfactory operating conditions, mostly caused by not being able to get a sufficient frictional contact between the belt and the pulley surfaces, which results in very tight belts, and consequently hard running shafting and used up belting.

HENRY D. JACKSON.

Boston, Mass.

Going over the Chief's Head

The editorial in the July 25 issue under the above caption is good as far as it goes, but it fails to say a word that will help the man who needs it the most, the manager who will encourage that sort of business.

This kind of manager seemingly does not realize that he is reducing the efficiency of his entire engine-room force at least 50 per cent., for every man in it is only keeping one eye on his work, the other being on the man who is suspected of running to the boss. Neither can this manager understand that a man who will "knock" his chief will, if opportunity offers, just as quickly knock the manager himself, or perhaps deliberately injure the company if he thinks it will further his own schemes.

In a town where I once worked there was a large ice plant employing two engineers; one was, by courtesy, called the chief. The title was an extremely hollow one, however, for he did not hire his help, nor have any great amount of authority over them. He merely had the day shift, did all the repairing and took the kicking, when there was any, all for an extra $10 a month.

The second engineer had been in that one position for five years, and during that time had worked with six different chiefs, every one of whom quit his job after having some trouble with this assistant. The manager made it a practice of coming to the plant in the evening, and the assistant usually conducted him around, pointing out the ways he would run the plant.

I was offered the chief's position, and agreed to take it, provided I was given entire charge of the engine room and of everyone in it, and if the manager agreed to keep out except when I was there. He refused, however, saying that it would be suicidal to allow any engineer to gain such control of the plant; that at any time he got a "grouch" he would quit and take his whole force with him.

Soon after this the assistant was detected in the act of putting soda into the reboiler to make white ice, and incidentally cause trouble for the chief. When this was brought to the attention of the manager he refused to credit it; he could not believe such a faithful man could be guilty of such an act, and he allowed the chief to quit. But later the manager saw his folly, when this assistant engineer told the largest stockholder in the company that the manager was putting in too much of his time during business hours in a nearby cigar stand playing "solo."

A short time ago I was visited by the manager of a plant in a distant part of the State, who made what appeared to be a very attractive offer, a larger and finer plant, a nice locality and a substantial raise in wages. My first inclination was to jump at it, but when I considered how few bosses there are like mine, and how many of the other kind, I refused the offer.

I am in charge of a small but growing plant, hire all my help, buy my supplies, and run or lay off as I think best. The manager would no more ask my assistant anything about the work than he would think of turning his checkbook over to him. All he seems to care for is that I furnish him with good ice whenever he needs it, and at a reasonable cost. He apparently does not fear that I will get angry and cripple the plant by leaving with my help during the summer rush.

ALBERT J. WICKES.

San Luis Obispo, Cal.

Value of CO_2 Recorder

No doubt exists in the minds of engineers but that boiler-plant efficiencies obtained in tests and special runs are rarely, if at all, attained in actual operation. Evaporations of 10 or 11 pounds from and at 212 degrees per pound of coal are often obtained in tests. When it comes to averaging up the monthly coal bill, however, and the monthly evaporation, it is found that the efficiency is considerably lower.

The boiler plant does not operate continuously; banked fires are carried, furnaces are cleaned and other operating conditions cause this discrepancy in the efficiency of steam formation. An additional reason, probably of as great weight, is that under actual operating conditions the boiler-room force is not keyed up to its best work and is not conscientiously and persistently working for a record.

What are the conditions attendant to boiler acceptance tests and special runs for making records which cause these high efficiencies of operation? The load is usually favorable, the coal is that best suited to the grate or stoker, and an expert whose experience and training have been along the lines of obtaining record boiler-plant performances, are all brought together. What proportion of the high efficiency obtained is to be accredited to the expert fireman and what proportion to other favorable conditions is, of course, an open question. The expert operator watches his fires with the very keenest attention; the smallest indication of a burnt-out hole gets his immediate care; he seems to know intuitively just what draft is needed at every moment, when and how much, and where to place his coal.

The result is that the loss of coal through the grates is a minimum. Similarly the loss due to the escape of combustible gases and the loss in smoke are held down to practically nothing. The loss of heat by radiation he cannot well regulate. Finally, the greatest source of loss in the boiler plant—the heat in the chimney gases—is held down to the very lowest figure.

That this loss up the chimney is low is proved conclusively by turning over the pages of POWER and other technical papers, and referring to the published tests of boilers, where it will invariably be found that with high overall boiler efficiencies, the percentage of CO_2 is high, indicating a small volume of waste gases carrying off heat. For instance, reference to the tests on page 721 of POWER (May 9, 1911), shows efficiencies as high as 83.3 per cent. with CO_2 as high as 14.3 per cent. In POWER for January 31, 1911, H. R. Mason gives tests where the percentage of CO_2 was 11.35 and the efficiency of boiler alone 74.2. A test of the electric plant at Vitry-sur-Seine (*Zeitschrift des Bayerischen Revisions-Vereins*, January 31, 1911), shows with CO_2 12.4 per cent., an efficiency of boiler and superheater of 77.92 per cent. Reference need only be made to other tests and acceptance trials for further evidence of the attendance of high per cent. CO_2 with high efficiencies. A study of 293 of the tests made by the United States Geological Survey at St. Louis shows (page 27, Bulletin No. 325, United States Geological Survey) that with an increase of CO_2 from 6 to 12 per cent. the efficiency increased from 54 to 66 per cent. In these tests the amount of air infiltration amounted to "50 per cent. of the volume present in the rear of the combustion chamber."

This letter has been prompted by the reading of Mr. Vassar's letter in your issue of July 11, and also his former correspondence, together with E. A. Uehling's criticisms.

Mr. Vassar points out that one of the great drawbacks to the use of CO_2 percentages as a guide to economical boiler-plant operation is that it is difficult to take CO_2 samples from the flue which are true averages and thus to obtain CO_2 percentages which are actually representative of plant conditions. Where a sample bottle is filled in a short time, it is entirely possible that the sample does not represent a true average of the flue gases. It may be added that, where a sample is taken over a long period, say, eight hours, the analysis is of no

value in studying the influence of load conditions, frequency of firing, thickness of fire, opening of fire doors, draft, etc., on the heat carried away in the waste gases. On the other hand, with a pneumatic CO_2 machine, drawing the flue gas continually from the flue in a considerable amount over that actually required for analysis and recording and indicating continuously the per cent. CO_2, the effect of small variations in the constituents of the sample of the gas being drawn at any instant of time are averaged up. The process might be compared to a method of coal analysis in which little pieces of coal were being continually taken from a coal chute through which all the coal passed. The average of the continuous analysis would be as true an analysis of the whole coal pile as that obtained with the method of selecting an average sample, irrespective of the fact that continuous sampling was done at the same point of the chute.

Both previous writers have agreed that many other things must be taken into account in the boiler plant before we can arrive at a conclusion as to the relation of combustion efficiency and per cent. CO_2. Other things being constant, it is, of course, certain that the smaller the waste in any given direction the greater will be the efficiency. But where the other factors vary, it is absurd to attempt to set down hard and fast rules concerning what percentage of CO_2 should be carried in a boiler plant. We might just as well say that a certain vacuum should be carried in all steam-condensing plants, regardless of the type of prime mover, what the cost of pumping the water is, or what the cost of the steam is, or how much it costs to run the auxiliaries or any other of the innumerable first costs and operating-cost figures, which should rightfully enter into the determination of the most economical vacuum. Still, we do not find engineers dispensing with the vacuum gage, because perhaps it is not economical to carry more than 27 inches vacuum in a given plant (since when above that vacuum the cost of attainment overbalances the economy obtained). On the contrary, we find the engineer continually striving to hold up his vacuum, and while at times he may overreach, the yearly average, which is the important item, remains at the high figure necessary for economy.

The principles of scientific management have shown that definite aims and ideals are absolutely essential to high efficiencies. It is found then that in scientific management there is always a goal for whose attainment strenuous effort is put forth. In the steam plant, and especially the boiler plant, these goals have been somewhat obscure. While the chief engineer is striving to show a low monthly or yearly cost per kilowatt-hour, the fireman strives to "make good" by shoveling coal as industriously as he can.

Scientific management teaches that the ultimate goal cannot be won without there being set down minor goals, which are to be aimed at day by day and result in the attainment of highest total efficiency.

Therefore, the engine is found equipped with an indicator, the switchboard with its electrical instruments, the condenser with the vacuum gage, the hotwell with its thermometer, the feed-water heater with its thermometer, the boiler with the draft gage, steam gage, feed-water meter, steam meter and the waste meter, a meter giving the percentage of carbon dioxide and the temperature of the flue gases. The engineer and fireman are supplied with small definite aims toward which they strive and in so doing the great goal of high plant efficiency over the whole year is obtained.

PAUL A. BANCEL.

New York City.

Central Station versus Isolated Plant

In the issue of July 11, Emmet Baldwin tells us that the plant he ran was turned over to the central station. It seems to me that if the details of this plant were made known, as well as the deal itself, it might be interesting.

In the first place, what price did the central station quote? If the plant is five miles from a railroad the chances of other plants in the vicinity are very slim. If the central station has to put up a long transmission line and then only furnish 93 horsepower, we would expect the price to be anything but low.

How much heat is required in the winter time? If the buildings are large, as the length of the steam line would indicate, this alone would be quite an item.

Is the plant motor driven now or will considerable money have to be expended for the new installation?

Is the high cost all due to the transportation of coal, or to other things which might be improved? Is the heating done with exhaust steam or is this used to heat up the atmosphere and live steam used for the interior?

Is steam used for other purposes about the plant?

Is there a feed-water heater in use? Why not send in a couple of the indicator cards for publication?

Why is it necessary to have 148 feet and seven elbows in the steam line from the boilers to the engines, and is it covered?

What is the size of the pipe that causes 25 pounds drop in pressure?

Are the gages correct? Many more questions could be asked.

I hope Mr. Baldwin will take this in the spirit in which it was written. As far as the writer knows, Mr. Baldwin may have the plant in first-class condition and it may be a legitimate case for the central station.

Probably 95 per cent. of the readers of POWER are interested in the survival of the isolated plant. The central-station people are not backward in advocating their cause. Let us have the details of some of these cases and let the readers line up on the side of the isolated plant and see what they can make of them.

JOHN BAILEY.

Milwaukee, Wis.

I can sympathize with the engineer in the big city who has the central station after his plant and has to fight to keep his job, for I have a central-station man after the plant that I am running. I helped this man to all of the ins and outs of the plant, and now he is trying to get a contract to run it. But, I am working hard enough to make a good showing and to convince the central-station man that there is no money in it for him. He will not bother me any more for a while.

Now, why should the engineers in any State or town take POWER to task for advertising anything in the advertising columns? That very advertisement against which they complain results in giving me the benefit of many men's best ideas for which I pay POWER about 4½ cents a copy. I study carefully all there is in each issue and I am not slow to take advantage of all the good things that suggest themselves to me and make use of them.

If an engineer has a plant that has an inefficient equipment, it is up to him to see that the management understands the case when central-station figures are being considered.

Not long since I called on an engineer running a small refrigerating plant. The plant was going and so was the engineer. The thermometer was going up all the time. The engineer was complaining that he could not get the brine tank cold enough to freeze any water. I stood around awhile taking in the condition of things. The thermometer was going up and the man in charge kept saying, "I don't know what is the matter." I knew, however, if the brine had been attended to as faithfully as his own tank, the thermometer would have been down to zero instead of 15 degrees above freezing, and the cost of ice would have been one cent a pound instead of 100 cents.

If these mulelike engineers would let a little sunshine into their foggy brains there would be no reason to kick against the central-station activity.

H. B. WILLIS.

Providence, R. I.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Alternating-current Power

With only voltmeters and ammeters, how can I find out the true power at the switchboard of an alternating-current station?

C. M.

You cannot ascertain the true power without using a wattmeter or else using a voltmeter, ammeter and power-factor meter together. In using the three instruments, all three readings must be taken at practically the same moment.

Power in a Three Phase Circuit

How is the power in a three-phase alternating-current circuit determined if no wattmeter is available?

M. H. M.

Take simultaneous readings of the voltmeter, ammeter (in one leg) and power-factor meter. Multiply the three together and multiply the result by 1.732; the final result will be the power in watts if the circuit is balanced—that is, if the total load is divided equally between the three legs.

Brine Mixtures

What is the right proportion of calcium chloride to water for a brine in a meat box? What should the brine test with a salometer? Does the salometer show the specific gravity? Does it do harm if ice collects on the pipes in the brine?

H. J. M.

To make a good brine for refrigerating purposes add about 24 per cent., by weight, of calcium chloride to the water. The specific gravity of this solution is 1.2, which is equivalent to 25 degrees Baumé, or 100 degrees on a salometer. This brine freezes at a temperature of 15 degrees Fahrenheit. It can be safely used for back pressures not lower than 7 pounds gage.

Ice should not be allowed to collect on the coils, as it acts as an insulation, preventing the transfer of heat from the brine to the ammonia.

Pressure in Standpipe

A vertical pipe 150 feet high contains enough water to create a pressure of 50 pounds per square inch at the bottom. Both ends of the pipe are closed and pressure gages are placed at the top and bottom of the pipe, air or steam being forced into the upper end of the pipe until the upper gage shows a pressure of 100 pounds per square inch. What pressure will the lower gage show? For a pipe arranged the same as before with the exception that compressed air at 51 pounds pressure per square inch is admitted at the lower end of the pipe, what pressure will be shown by the gage at its highest point?

B. W.

The gage at the bottom of the pipe will register the pressure due to the hight of the water, plus the pressure of the air above the water, or

$50 + 100 = 150$ *pounds per square inch.*

In the second arrangement, the air will enter the pipe until there is a pressure of 51 pounds at the bottom of the pipe, and 1 pound at the top. Then the water pressure will balance the air pressure and no more air will enter the pipe.

Percentage of Clearance

How can I calculate the percentage of clearance in an engine cylinder 42x72 inches? The piston is ⅛ inch from the head at the end of the stroke.

A. L. J.

Clearance is the volume between the piston and the face of the cutoff valve when the engine is on the center. To measure it, place the engine on the center, close the exhaust valve and fill the space with water up to the level of the steam or cutoff valve, being careful to avoid air pockets. The percentage of clearance is the clearance volume thus determined divided by the piston displacement and multiplied by 100. If, for instance, your 42-inch engine had a stroke of 6 feet, or 72 inches, the displacement would be

1385.4×72 *inches*

(1385.4 is the area of a 42-inch circle). If it took 3000 cubic inches to fill the clearance space the percentage of clearance would be

$$\frac{3000 \times 100}{1385.4 \times 72} = 3 \text{ per cent.}$$

This must not be confounded with the mechanical or "striking" clearance, which is not expressed in percentage of the stroke but by its actual measurement. The striking clearance of the engine would be said to be ⅛ inch.

Pitch Diameter of Gears

If a gear has 22 teeth and is 6 pitch, how far will a rack be moved in 2½ revolutions of the gear?

H. C. B.

The pitch is the number of teeth divided by the pitch diameter. Hence the number of teeth divided by the pitch will give the diameter

$22 \div 6 = 3\frac{2}{3}$ *inches*

The circumference is

$3.1416 \times 3\frac{2}{3} = 11.52$

In 2.5 revolutions it would therefore move the rack

$11.52 \times 2.5 = 28.8$ *inches.*

Position of Shunt Field

Is there any difference, electrically speaking, in having the shunt field of a compound-wound, direct-current generator nearest the armature on the pole?

S. S. H.

Yes, a slight difference. The series winding is usually put next to the end of the pole because the leakage of magnetism produced by it is less there and its effect on the armature is greater than if it were put next to the yoke. With the series winding next to the pole, the shunt winding, of course, must go next to the yoke if they are side by side.

Cause of High Discharge Pressure

The pressure of the discharge from our ammonia compressor has increased greatly. What is the cause?

S. H. S.

A high discharge pressure in an ammonia-compression system may be due to too little cooling water showered over the condenser; too high a temperature of the cooling water; too small an effective cooling surface for the refrigerating effect required and to air and other fixed gases in the system.

The best way to remove these gases where open-air condensers are used is to shut off each condenser section from the system separately. Allow the cooling water to flow over the section shut off for from 5 to 10 minutes so as to be sure that practically all the ammonia is liquefied. Then shut off the water supply to this section and open the purge valve at the end of the top pipe slightly. As soon as frost appears on the outlet end of this valve, or when fumes issue, it should be shut immediately. Each condenser section should be purged in the same way.

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POWER

Water in Power Plant Piping

Water in the steam pipes of a power plant is to be avoided as much as possible. Its presence to some extent is, of course, inevitable—even in pipes carrying superheated steam there may be some water along the bottom of the pipe—but the quantity may be reduced to the minimum by the use of nonconducting coverings which retard the transfer of heat from the steam to the air. At a velocity of one hundred feet per second, which is not an unusual speed for steam in the pipes in the modern power plant, the water, if not taken care of, is liable to be caught up in slugs and carried along with the steam to be arrested at the first short turn or at the end of the pipe.

Just as a sixty-mile gale raises great waves on the ocean, so will a current of steam of high velocity raise waves from the water in the pipe or carry the water along by friction to the engine or turbine where a very small quantity of it may do a great deal of damage. If a pipe has a uniform pitch from its highest point to where it turns to the engine or turbine, there is no danger that enough water will collect anywhere to form a slug. But if there are low places or pockets, they will fill with water while the steam is quiet, and when the current starts it will be thrown into billows which, whether high enough to fill the pipe or not, will rush along with the steam and produce water hammer, start leaks and perhaps wreck a fitting or the pipe.

To prevent this, drain pipes should be connected which will under all circumstances take care of all of the condensation as rapidly as it forms. It is needless to specialize the parts of any pipe system requiring drains, for wherever steam circulates it condenses; therefore, these drains should be ample in size, properly located and kept open all of the time.

Branches of any considerable diameter leading from all pipes should be provided with stop valves at the highest point if possible, so that condensation cannot accumulate. If it is not practicable to so place all of them, those that may pocket water should be equipped with drains just above the seat.

In some systems of piping the main line is arranged to be cut into sections if so desired. Such sections when "dead" should be drained to the atmosphere to prevent filling with water from other sections through leaking or partially closed valves.

Mr. Zoelly's Views on Steam Turbines

Much interest was aroused by the announcement that Mr. H. Zoelly, inventor of the turbine which is built by the Zoelly syndicate all over Europe, would present a paper at the Zürich meeting of the Institution of Mechanical Engineers. The paper, an abstract of which appears on pages 318-322, hardly realizes the expectations which were aroused by the prominence and ability of its author. It proves to be little more than a description of the Zoelly turbine as built by Escher, Wyss & Co., which is, of course, very interesting, but does not satisfy one's desire for more analytical information.

Mr. Zoelly advocates throttle governing and says that it "works particularly economically at partial loads," just when the baleful effects of the excessive throttling would be expected to be greatest, backing up his assertion by reference to tests where the consumption varied only as follows:

Load, Per Cent. Rating	Relative Water Rate	Relative Thermal Efficiency Referred to Steam: Unthrottled	Relative Thermal Efficiency Referred to Steam: Throttled
104.7	1.000	1.000	1.000
77.3	1.039	0.964	0.994
55.0	1.087	0.920	0.994
28.4	1.208	0.872	1.021
102.6	1.000	1.000	1.000
75.7	1.048	0.953	0.997
51.3	1.114	0.923	1.011
25.5	1.329	0.834	0.997
99.5	1.000	1.000	1.000
80.4	1.056	0.954	0.991
50.1	1.190	0.875	0.958
26.9	1.450	0.819	0.973
102.9	1.000	1.000	1.000
79.1	1.042	0.937	0.980
50.5	1.115	0.881	0.975

The last column is based upon the efficiencies referred to the steam after it has been throttled and not including the loss due to throttling. If the figures are right, and they will be found to correspond to those in the paper (see page 322), the blading of the first turbine was more efficient at a quarter and that of the second at a half than at normal load, while the third was more efficient at quarter than at half load. When the efficiencies are referred to the steam as

furnished to the turbine and include the effect of throttling they run down as the load is decreased, as would be expected. It would have been interesting if the author had expanded his statement that this economical working at partial loads "is only possible when simple velocity wheels are used in connection with parallel guide nozzles throughout the whole turbine, and provided that the most favorable choice is made in regard to the subdivision of stages."

Mr. Zoelly says that the many tests which he has made "all go to show that it is not possible to obtain a higher thermal efficiency with compound-velocity wheels than fifty-eight per cent., whereas with a turbine designed with simple-velocity stages it is possible to obtain an efficiency of seventy-three per cent. and more." Curtis turbines, in which the compound-velocity stage is used throughout, have shown at the Commonwealth station in Chicago a thermal efficiency of 69.8 per cent., at the Waterside station of the New York Edison Company of 70.5 per cent., and at the L-street station of the Boston Edison Company 72.2 per cent.

The author declares against the use of the compound-velocity blading even for the initial stages except where, as in marine work, slow rotative speed is imperative. Yet the highest efficiencies so far attained have been produced by combination turbines having compound-velocity initial stages. These, however, had Parsons or reaction blading for the rest, and his comments in this respect are restricted to impulse turbines.

The argument, not entered into in the paper, against the compound-velocity stage is that the first blade takes out the greater part of the energy, leaving too little to the second to justify its use. When a parallel instead of a divergent nozzle is used, as Mr. Zoelly advocates, the steam will go on expanding in the blades as its energy is absorbed, increasing the velocity in the second row and making it do a larger proportion of the work. A little discussion of this fact, of the modification of the blading found desirable to meet these conditions, and similar topics, would have made the paper appear more as though it were Ingenieur Zoelly rather than Director Zoelly who was talking.

Sand for Hot Boxes

Liberal applications of sharp sand to a hot bearing for the purpose of reducing its temperature would be considered by most engineers as both heroic and dangerous treatment. But there are many instances in which the use of sand or any of the softer kinds of grit, such as rottenstone or grindstone dust, will prove highly beneficial. Often the natural shrinkage of the metal in a rebabbitted box will pinch the shaft to such an extent that some metal must be removed before cool running is possible; sometimes a bearing gets "dry" and the surface of the babbitt is "wiped" or swept part way around the box, thus causing the shaft to bind. In either of these cases the surfaces may be brought into satisfactory running condition by feeding sand and oil or sand and water to the bearing until it runs cool.

Sapolio is used by a number of erecting engineers for the purpose of bringing the main bearings of new engines into the proper working condition. With the cap off, the engine is run at normal speed with a small stream of water or oil playing on the shaft, and a cake of Sapolio held in the hand is slowly moved from end to end of the bearing until the shaft shows bright the whole length.

On many ocean steamers a box of sand is a part of the engineer's emergency outfit, and it is kept handy for use in case any of the propeller-shaft bearings begin to heat.

Power Plant Design

Some plants are so well laid out that even though they are allowed to get a little "down at the heel" they still show fairly good economy. Other plants, poorly laid out by more or less incompetent and inexperienced men, are so handicapped from the very beginning that to secure reasonable economy with them requires surpassing effort.

The particular build of boiler or engine selected does not make any very great difference so long as the type is suitable for the purposes of the plant. But the sizes of the various pieces of apparatus and their arrangement may make vast differences in the results the plant will yield. Take, for example, the matter of chimney design. A surprisingly large number of plants are handicapped by undersized chimneys. Usually the trouble is that the chimney is too short.

The capacity of a chimney depends upon its cross-sectional area and its hight. The capacity increases directly as the area and directly as the square root of the hight. The comparative cost of a chimney increases but slightly with an increase in diameter or cross-sectional area, but it increases greatly with an increase in hight. Hence, the designer is tempted to select a short chimney of large diameter rather than a taller chimney of smaller diameter. He loses sight of the fact that the draft depends upon the hight and that any chimney, no matter how ample in diameter, is inadequate if it cannot furnish enough draft to pull the air through the fuel bed.

Thus, while the designer may succeed in saving a few dollars in the first cost of a plant, he often condemns it to perpetual inefficiency which in the end may assume unbelievable proportions.

The Engineer's Place Is in the Engine Room

Should the operating engineer be compelled to leave the engine or boiler room while it is in operation, especially when he does his own firing? Aside from the matter of safety, can the manufacturer afford to allow the machinery in the steam plant to operate without an attendant at hand?

By compelling the engineer to do outside work, a saving of a few dollars may be made, but one slight accident, which probably could have been prevented had the engineer been present, will wipe out all of the saving made by the outside work he had done.

An engineer, especially in a small plant, has several unemployed hours each day, but his presence is necessary nevertheless. Numerous flywheel explosions have been prevented because the engineer was at hand and shut the throttle valve in time. Crank-pin boxes have been saved because the man on watch was attending to his duties when the oil cup failed to feed. Tubes in boilers will sometimes burst, but if the fireman is out in the yard handling scrap iron he has not much chance to cut out the boiler in such an event, and thus prevent a shutdown of the entire establishment.

An engineer recently took charge of a steam plant in which the fireman made his work a continuous performance. This apparent industry satisfied the superintendent perfectly; he did not take into consideration the fact that every time the furnace doors were needlessly open or the fires sliced and leveled there was an inrush of cold air which cooled the furnace gases and cost money.

As the result of the changes made by the new engineer, one boiler was cut out of use and the fireman had time to sit down a few minutes between each firing.

The superintendent then objected to the fireman thus wasting the company's time, and insisted that when he was not busy in the boiler room he be employed on some outside work.

This superintendent does not stand alone in his attitude toward the men in the steam plant. It is a common matter to find an engine or boiler room deserted because the attendant had been compelled to do other work than his own.

This being a "Jack of all trades" has prevented the engineer from gaining a higher place in the estimation of his employer. It should be the engineer's aim to convince those over him that his place is in the engine room and that he can save more money for his employer by attending to his own affairs than he can by going outside and doing the work of others.

Heating and Ventilation

Considered as power plant problems. Layout and operation of systems and apparatus

Measurement of Air Velocities

By F. G. Hechler

In heating and ventilating work it is often necessary to determine the amount of air supplied by a fan, and especially in acceptance tests is it necessary to determine the quantity exactly. The volume of air is expressed in cubic feet, and as it is nearly always conducted from the fan through a duct either circular or rectangular in cross-section, the cross-sectional area of the conduit and the velocity of the air through it should be known as well. The product of the area in square feet by the velocity in feet per minute gives the cubic feet supplied per minute.

The velocity may be determined in several different ways, though the most common method is by the use of an anemometer, a small-vaned instrument similar to a windmill wheel. The wheel is connected with a recording mechanism by the use of which in connection with a stop-watch, or even an ordinary watch, the speed of the air past the vanes may be determined. Its convenience is the only thing to recommend an anemometer, however, as its readings are subject to large and uncertain errors. The makers always supply rating tables with these instruments, which show the actual velocity corresponding to any apparent velocity as determined by the instrument. These tables do not show any particular uniformity in the matter of error at the different velocities, and after the instrument has been in use a short time it is likely to give quite different results, due to wear and dirt getting in the delicate bearings. But even with frequent calibration they will be reliable only if rated under conditions similar to those under which they are to be used. To show the importance of this, tests made by a prominent engineer on the measurement of the velocity of air in pipes by an anemometer showed that the percentage of error is not constant and that it varies with the size of the pipe and the speed of the air. The size of the pipes varied from 8 to 24 inches in diameter, and the velocities as given by the anemometer varied from 14½ per cent. fast to 39.6 per cent. slow, as compared with the true velocity determined from the time of descent of a large gas holder of known capacity.

It is well known that the velocity of air in a pipe line is not the same at all points, being greatest at the center and least at the sides, where friction against the surfaces retards it. For a circular pipe the law of variation is usually taken to be a parabola; the air moving in concentric layers with the average velocity at a point two-thirds of the radius from the center. This variation in velocity may partly account for the uncertain results obtained with an anemometer, and it is evident that an instrument properly calibrated may give too high a reading if held at the center of a large duct.

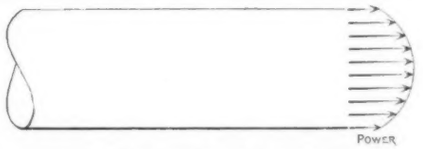


Fig. 1. Velocity of Air in Pipes

A better way to determine the velocity, and one which gives much more reliable results, is to use a Pitot tube. To make clear the principles on which the use of this instrument is based, its use for determining the velocity in a water main will be considered. Water is a more concrete substance than air and hence it is easier to deal with it; but exactly the same laws apply in regard to the velocity of air as hold for water.

A pressure gage connected to a pipe line will show a higher pressure with no flow than when the water is in motion, and the faster the flow the lower the pressure shown by the gage. When there is no flow the gage shows the total or static head; when the valve is opened and flow occurs a part of this head is used up in causing the water to flow. In other words, a "velocity head" is necessary to produce motion, the remaining head shown by the gage being the "pressure head." If the pipe were perfectly smooth and there were no friction losses, the sum of the velocity and pressure heads would always equal the static head shown when there is no flow. The friction losses are variable and not easily measured, but the Pitot tube gives a ready method for finding the velocity head, and from that the velocity, as shown later.

If a tube be inserted in a pipe line, as at *A*, Fig. 2, with its inner end parallel to the axis of the pipe and hence to the direction of flow of the liquid or gas, and the outer end connected to a U-tube filled with water or mercury (depending on the pressure to be measured), the difference in the hight of the two columns represents the pressure head expressed in inches of water or inches of mercury. If a second tube be placed, as at *B*, with its end bent at right angles so that it is perpendicular to and faces the flow of the stream, its manometer tube will give both the pressure head and the velocity head. If then the difference between the readings of *B* and *A* are taken, the velocity head producing flow is obtained. For convenience, these two separate gages are usually combined into one, as shown at *C*. Here the tube at the left, similar to *A*, tends to show the pressure head; the tube at the right, similar to *B*, shows the pressure head and the velocity head; in other words, connecting the tubes in this manner automatically performs the above subtraction and the reading of this gage represents the velocity head.

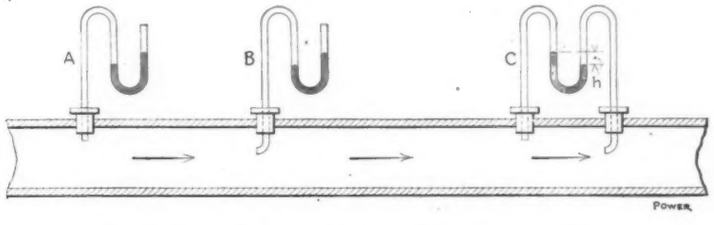


Fig. 2. Pitot Tube to Measure Velocity of Air

After the velocity head is found, the velocity is calculated by the formula

$$v = \sqrt{2gh},$$

where

v = Velocity in feet per second;
h = Velocity head in feet;
g = Acceleration due to gravity in feet per second per second = 32.2 feet.

If the manometer contains water and

the velocity of air is being determined, then the head must be changed from inches of water to feet of air by multiplying by the ratio of the density of water to that of air. To do this the temperature must be known, as the weight of a cubic foot of air and of water depends on the temperature. To illustrate, assume that the manometer reading h, in Fig. 2, is 1 inch of water and that the temperature of the water and of the air is 60 degrees Fahrenheit. From tables the weight of 1 cubic foot of water at 60 degrees is 62.37 pounds and of 1 cubic foot of air at the same temperature is 0.0764 pound, or the hight of a column of air in feet to represent the same pressure as 1 inch of water would be

$$\frac{62.37}{0.0764} \times \frac{1}{12} = \frac{816.4}{12} = 68.03 \text{ feet}$$

Using the equation

$$v = \sqrt{2gh} = \sqrt{2 \times 32.2 \times 68.03} = 66.2 \text{ feet per second}$$

For any other temperatures, or if mercury is used in the place of water, the proper weights per cubic foot would have to be used.

Heating and Ventilating High School Buildings*

By Samuel R. Lewis

This paper outlines the scheme of heating and ventilating a new schoolhouse building in Decatur, Ill., and the remodeling of the heating and ventilating apparatus in an established high-school building, together with the scheme followed for supplying both buildings with steam for heat, electric light and power from a central point.

The new building is about 500 feet distant from the old building, which was formerly heated by 10 warm-air furnaces. The ground space for the new building and its surroundings made it desirable to eliminate a boiler plant, and as the furnaces in the old building were worn out at the time of the designing of the new building, it would have been necessary to install new heating and ventilating apparatus. As the old building is of nonfireproof construction, it was proper to remove all fire from within it. The new building was to be completed in the spring of 1911, and the old building must be provided with a new plant in the fall of 1909. These considerations prompted the location of the power house adjacent to the old building, especially as coal-storage space could be obtained under it, and it would be possible to provide enough capacity to handle the old building through the winter at minimum cost.

It was decided to install the indirect type of heating, well governed by automatic regulation, as being the most positive and sanitary as well as economical.

Direct radiation is used in all toilets, offices, corridors or rooms with plumbing which might be injured by excessive cold; having direct radiation in class rooms tends to keep them warm when the fans are not in operation, provided they are furnished with steam. At Decatur the buildings were so arranged as to group the indirect radiation in small chambers near the banks of flues, and thus by gravity air circulation keep the rooms reasonably warm without any direct radiation when the fans were not in operation. This method is remarkably successful.

The boiler house is fireproof, and contains three high-pressure horizontal

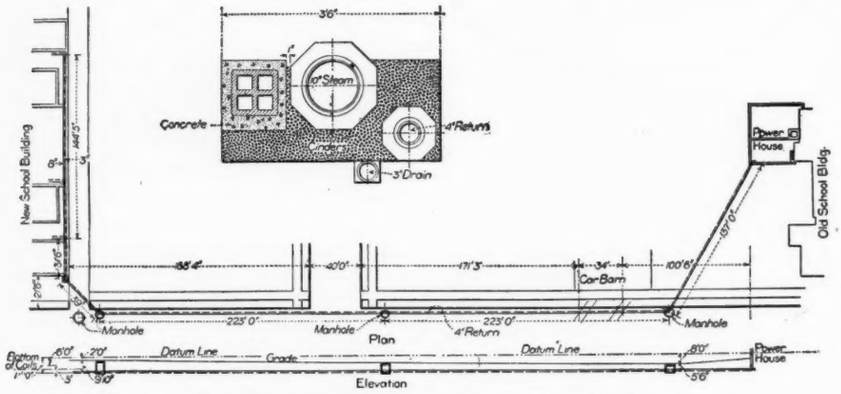


Fig. 1. Underground Conduit to New School Building

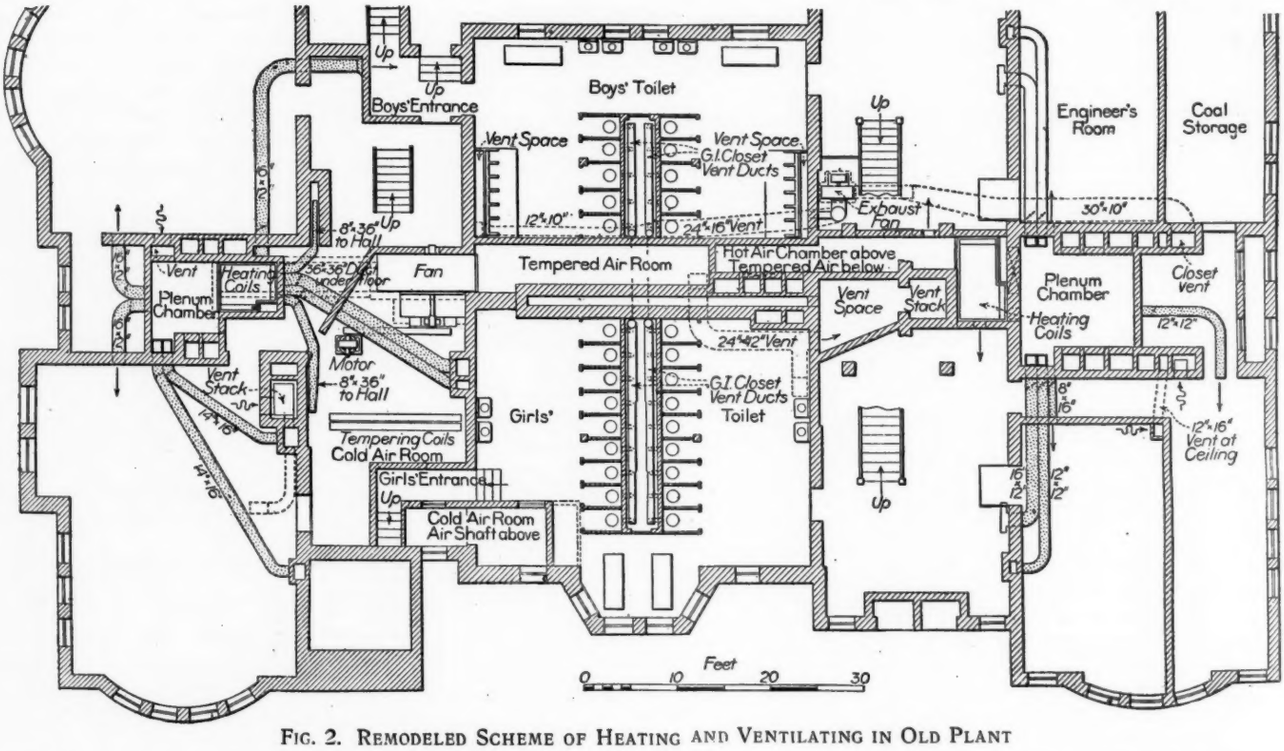


Fig. 2. Remodeled Scheme of Heating and Ventilating in Old Plant

*Abstract of paper read before the American Society of Heating and Ventilating Engineers, Chicago, July 6 to 8.

tubular boilers of 450 rated horsepower with standard equipment for bituminous coal. In a room adjoining the boilers are the feed-water heater, boiler-feed pumps, all main operating valves, pressure regulator, etc., and two horizontal turbine-generators, with the accompanying switchboards. The distribution lines for steam, compressed air and electricity center in this room. The generators are for 250-volt direct current; one is of 75 kilowatts capacity and the other a 50-kilowatt machine.

To the old building are run a 7-inch steam line and a 2½-inch wet return, and to the new building, in a common trench 650 feet in length and from 4 to 12 feet underground, are carried a 10-inch steam and a 4-inch wet return, in tin-lined Wyckoff insulation, and a four-part vitrified-tile electric conduit. The main to the new building pitches upward from the boiler house, and as it is below the receiver, the condensation in it is raised to the receiver by a tilting trap. Proper expansion joints and anchorages are inserted, the former being accessible in brick manholes.

In the old high school the supply fan is a special Sirocco wheel driven by a belted 15-horsepower motor, delivering tempered air to horizontally placed reheating coils in plenum chambers directly at the bases of the flues. Fresh air is drawn from the second-story level. All the toilet rooms have special closets, with large rear local vent openings, and all urinals are locally vented, being connected by metal ducts with an exhaust fan, which is driven by a direct connected 2½-horsepower motor. New tile flues supplement the old flues and in the attic are placed cutoff dampers in all vent flues for shutting off the ventilation when the building is not occupied. This is effected by compressed air from the engine room.

All class rooms have automatic temperature regulation, the thermostats gradually moving the mixing dampers in the plenum chambers without curtailing the volume of air, merely changing its temperature as required. Cumulative devices are installed by means of which the power of the entire plant finally goes to the slowest room to reach 70 degrees when warming the building in the morning. On all side-wall air-supply openings are placed adjustable diffusers, by which the air currents may be deflected to any part of each room. There are no vent screens or registers in the new building, the ventilation outlets being finished as far as visible like the rooms, and thus they are swept out every day, preventing the unsightly accumulation of dust, chalk and paper common when screens are used.

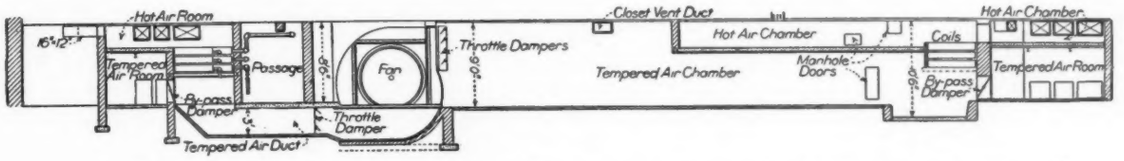


FIG. 3. SECTIONAL ELEVATION THROUGH REMODELED HEATING AND VENTILATING PLANT

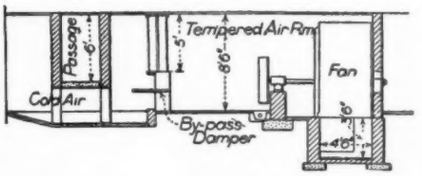


FIG. 4. AIR PASSAGE TO FAN, OLD BUILDING

The old high-school building has an air delivery of 43,000 cubic feet of air per minute, and about 3600 square feet of indirect radiation. The air blown into the corridors finds its way out through the toilet rooms by the locally vented fixtures, and thus there is always a greater air pressure in the former than in the latter, thus effectually preventing odors from the toilets being noticed anywhere in the building. The toilet ventilation is entirely separate from the room ventilation.

The new high school was naturally an easier and more symmetrical problem, but the description of the apparatus in the old building will very nearly suffice for the new one. The fresh air is drawn from the second-floor level, and is tempered and delivered by the fans into a tunnel which extends under the center of the corridor around three sides of the building. This tunnel has nine groups of reheating coils and all of the piping for steam and condensation. The tunnel is of ample size for easy inspection, can be flushed out with a hose, and is well lighted with electricity. There is very little use of metal-duct work. By closing the doors to the various other coils

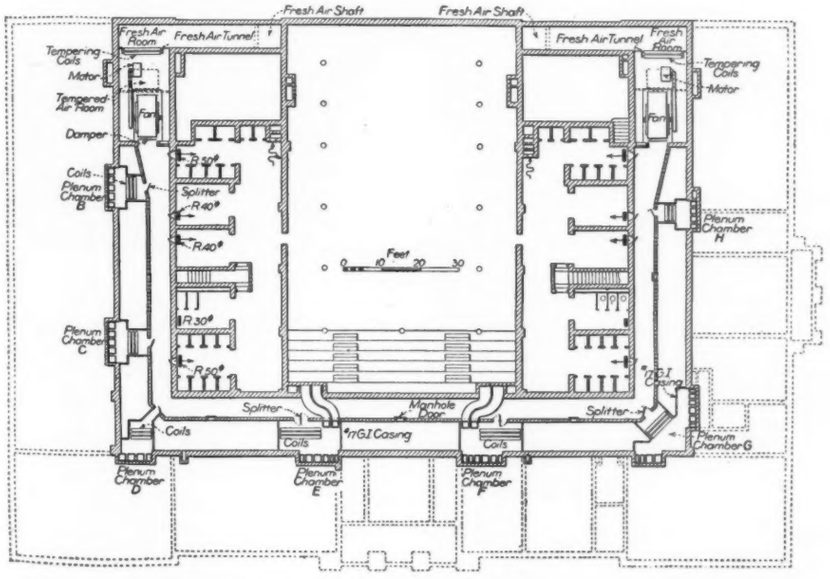


FIG. 5. HEATING AND VENTILATING SCHEME IN BASEMENT OF NEW BUILDING

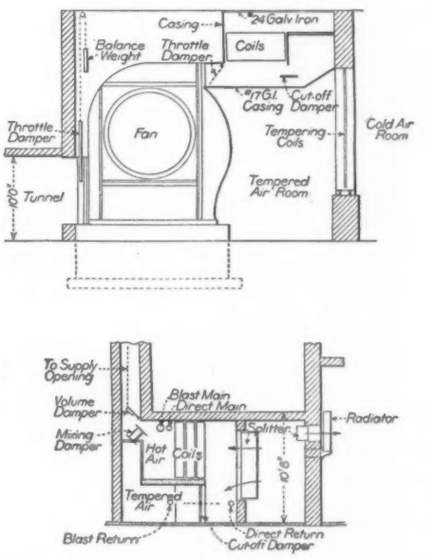


FIG. 6. DETAILS OF NEW BUILDING PLANT

the auditorium or gymnasium may be ventilated or heated by either fan without affecting the balance of the building. The supply fans are Sirocco wheels in double discharge housings propelled by 20-horsepower belted motors. The building receives 120,000 cubic feet of air per minute, and there are about 9000 square feet of indirect radiation.

Exhaust fans for toilet and chemical-table ventilation are placed in the attic which, together have a capacity of 15,000 cubic feet of air per minute and have 8 horsepower in motors. The chemical-laboratory ventilation is carried in vitrified-tile pipes and the fan which handles the fumes is of special corrosion-resisting construction. A large, tight foul-air chamber is formed in the roof space from which the foul air escapes through ventilators equipped with compressed-air controlled dampers as described for the old building. In both the old and the new buildings the foul-air chambers in the attic may be thrown in connection with the fresh-air intake flues, thus forming a closed circuit through which the air may be recirculated over and over positively; a substantial fuel saving is thus effected when warming the building prior to occupancy.

Each room has in its supply flue a volume damper operated from the back of the diffuser in the room but located in the inlet to the flue in the basement. This arrangement is of great convenience when adjusting or testing the air distribution, besides eliminating any unauthorized manipulation of the dampers, as is common with the ordinary type.

The locker and shower rooms in the subbasement of the new building and all corridors have both direct radiation and air supply from the indirect system. Whenever possible the air is delivered through or against the direct radiation, thus increasing its efficiency about three times and preventing local circulation.

Flywheel Explosion at West Berlin

By W. E. Chandler

An account of the flywheel explosion which occurred at West Berlin, Mass. This article, from the pen of the chief engineer of the plant, gives additional information as to the probable cause of the accident.

The accompanying illustrations show to some extent the damage done on July 4 to the power plant of the Worcester Consolidated Street Railway Company, at West Berlin, Mass., an account of which was published in the July 25 issue of POWER. The cause of the accident was stated by J. W. Parker, the author of the article, as doubtless being due to the governor safety device failing to work. The facts do not bear out his conclusions.

The plant consisted of two 20x42-inch simple Corliss engines; No. 1 was a right-hand and No. 2 was a left-hand engine. No. 1 engine, the wrecked unit, was belted to a 225-kilowatt, direct-current generator. It was quite an old machine and the commutator was nearly worn out. No. 2 engine was belted to a direct-current generator of the same capacity, but it had a new armature and commutator. One unit made 86 and the other 89 revolutions per minute.

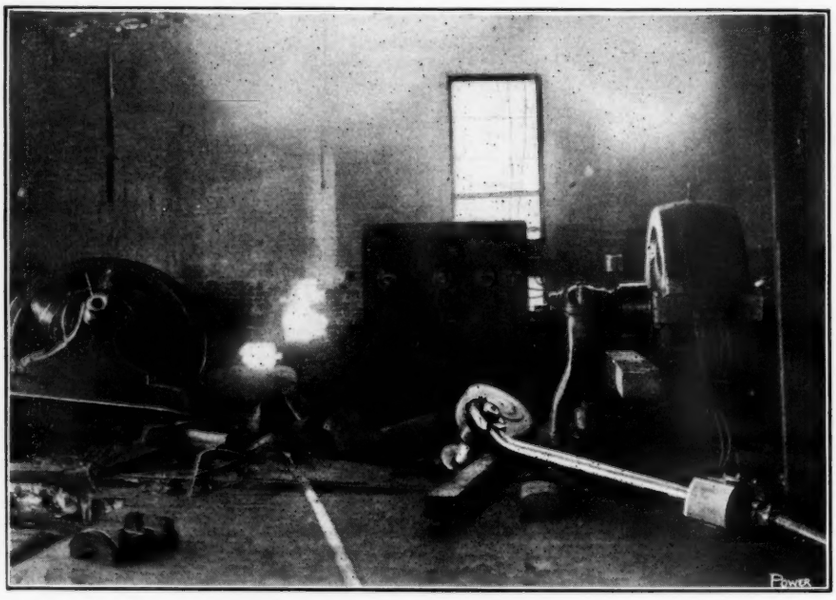


FIG. 1. WRECKED GENERATOR AND PARTS OF THE ENGINE

Both engines were connected to the same jet condenser which was placed in the basement between the two engines, directly below the gageboard shown in Fig. 1.

On July 2 and 3, I had sandpapered the commutators and trimmed the brushes of both generators and thoroughly inspected, adjusted and tested both engines, as I expected a heavy day on the fourth, and every precaution was taken to guard against failures at the station.

Inspector Ramsay, of the boiler-inspection and engineers-examining department of the district police, investigated the wreck shortly after the accident occurred and expressed himself as being satisfied that it was not caused by either neglect or carelessness on the part of anyone.

Both governors were in perfect working condition and so were the governor belts. No stop pin was used on the engine, as an idler and its connections running on top of the governor belts kept the weight up at slow speed. If the belt broke, or got too slack at any time, the steam-valve gear would not hook on. These engines were each designed to carry a load of 409 amperes, and I have often stood beside the governors and watched them when carrying 550 amperes. A circuit-breaker would go out, but the engine would be at normal speed in three strokes; therefore, the faulty-governor idea can be dismissed.

No flaw was found in any part of the flywheel and a prominent engine builder after looking over the broken pieces stated that it was of remarkably good material. The engines had been run for 12 years, and were still in good condition; so that any charge of poor material and workmanship cannot be proved.

The valves and cylinder were found to be well lubricated and no signs of water were evident; thus sudden stoppage cannot be entertained as the cause.

My theory is that as the commutator on No. 1 machine was very light, it would blacken up after a 10- or 12-hour run and cause the voltage to drop. No. 1 machine had been on the line 14 hours and No. 2 was on 16 hours; the three hours just previous to the accident were the heaviest of the day. At 9:30 the entire load went off suddenly and

No. 2 machine, being at a slightly higher voltage, would cause current to flow through the series windings of No. 1 machine in the reverse direction; this would weaken the field and finally motor the machine. The circuit-breaker had been expanded from the heat of the few days past and would not open. As a result the engine at once reached a high rate of speed and the outboard bearing tore loose from its bedplate and was thrown over No. 2 generator and through the wall, making the hole shown in the upper right-hand corner of Fig. 1. This allowed the crank shaft to swing and break out the outer side of the main bearing as shown in Fig. 2.

The rim of the wheel struck the foundation of the frame and main bearing, breaking it and throwing one piece weighing about 3800 pounds off the wheel through the roof, and landing 460 feet distant. Another piece weighing 1800 pounds went through an 18-inch wall between the engine and the boiler rooms, just above the steam main, and landed between Nos. 1 and 2 boilers. No damage was done to either except to slightly bend a 1-inch valve stem on the vent pipe, and break the fulcrum of the lifting lever of a safety valve. Three more pieces of the rim went through the same wall into the cellar, cutting off a 7-inch condenser suction, an 8-inch condenser discharge and a 14-inch main exhaust pipe. A 2-inch auxiliary steam line and an auxiliary exhaust line were also severed. One piece struck the blowoff pipe of No. 1 boiler and bent it 4 inches out of line.

The crank shaft, flywheel hub and one spoke, the crank, connection rod, crosshead and piston rod, which was pulled out of the piston (which was not even cracked), landed in the position shown in Fig. 1. It knocked No. 1 generator off its base and turned it partly around, as shown in Fig. 1. Two spokes went directly past the generator and through a 12-inch wall, burying themselves in the ground 75 feet away. Another piece struck the brush-holder frame of No. 2 generator and ruined it, also slightly denting the commutator to the extent that it was necessary to turn it down.

The flywheel was 16 feet in diameter, and the rim face was 30 inches wide and 3½ inches thick. It was made in two sections, three spokes to each half. The hub was 36 inches square and 30 inches wide and was held together by four 4-inch bolts. Each rim flange was bolted together with four 3-inch bolts. The spokes were 13½ inches wide at the hub and 10¾ inches wide at the rim.

The eccentric rod pulled out of the strap, breaking the wristplate hub and valve gear. The governor shaft was sprung, but not broken.

The writer was chief engineer of the station at the time the wreck occurred, and hunted for the cause of the accident for four weeks before he was satisfied that the theory expressed herein was the correct one.

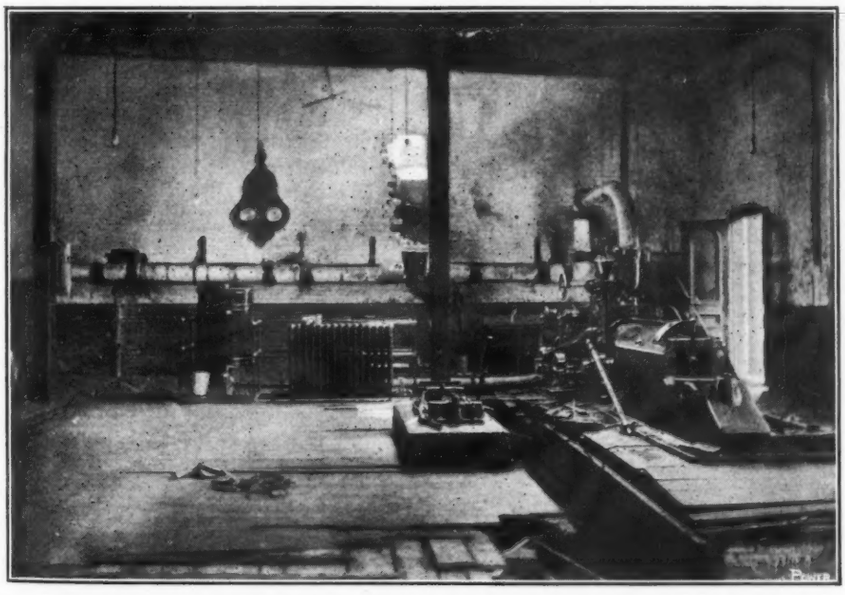


FIG. 2. WHAT WAS LEFT OF THE ENGINE

Program of Annual Meeting of the I. O. E.

The convention committee of the Institute of Operating Engineers has arranged the following program for the first annual meeting which is to take place at the Engineering Societies building, 29 West Thirty-Ninth street, New York City, on September 1, 2 and 3:

Friday, September 1, registration at booth on main floor, 9 to 10 a.m.; opening session in room 2, on the fifth floor, 10 a.m. The address of welcome will be made by the Hon. William S. Bennett. Short addresses will be made on "The Operating Engineer's Future," by F. R. Low; "The Engineer's Place in the Community," by D. B. Heilman; "The Employer and the Engineer," by A. C. Dougall. At their conclusion various committees will be appointed and instructed by the chairman.

The afternoon session will be called to order in room 2 on the fifth floor at 2 o'clock. This session will be given over entirely to the reading and discussing of the following papers: "Temperature Changes and Heat Transmission," by Vernon L. Rupp; "Boiler-Room Analysis of Coal," by J. P. Fleming; "Cooling Towers versus Steam Pumps," by Henry W. Geare.

The evening session will be called to order at 8:15 in room 1 on the fifth floor. Addresses will be made by Prof. W. D. Ennis and F. H. Sykes, and an illustrated paper will be given by J. A. Pratt on "A Method of Teaching Operating Engineering."

At the 10 a.m. session on Saturday, September 2, in room 2 on the fifth floor, new business will be transacted, the reports of the committees will be received and discussed and the election of the national officers for the coming year will be held.

The afternoon session, at 2 o'clock in room 2 on the fifth floor, will be devoted to the following technical papers: "Engine Lubrication," by R. D. Tomlinson; "Reduction of Lubricating Costs in Smelter Power Plants," by G. L. Fales; "Removing Emulsified Oil from Condensed Water," by Darrow Sage.

In the evening at 8:15 a visit will be made to the power house of the Interborough Rapid Transit Company.

The program for Sunday, September 3, has not been announced, but it is expected that the day will be spent in sightseeing trips about the city.

LADIES' PROGRAM

A committe to provide entertainment on Friday for the ladies of the members and friends of the Institute has arranged for visits to the New York Public Library at 10 a.m., and to Ellis island at 2 p.m., and a public meeting in room 1 on the fifth floor of the Societies building, at 8:15 p.m.

For Saturday visits will be made to the museums of Art and Natural History at 10 a.m., the botanical and zoological gardens in the Bronx park at 2 p.m., and the Interborough Rapid Transit power house at 8:15.

On Sunday all who so desire may attend the services at the Union Theological Seminary at 11 a.m., or at the Cathedral of St. John the Divine at the same hour.

The committee consists of Mesdames Jurgensen, Collins, Elder, Lawrence, Eastment and Stewart and Miss Bjerregaard.

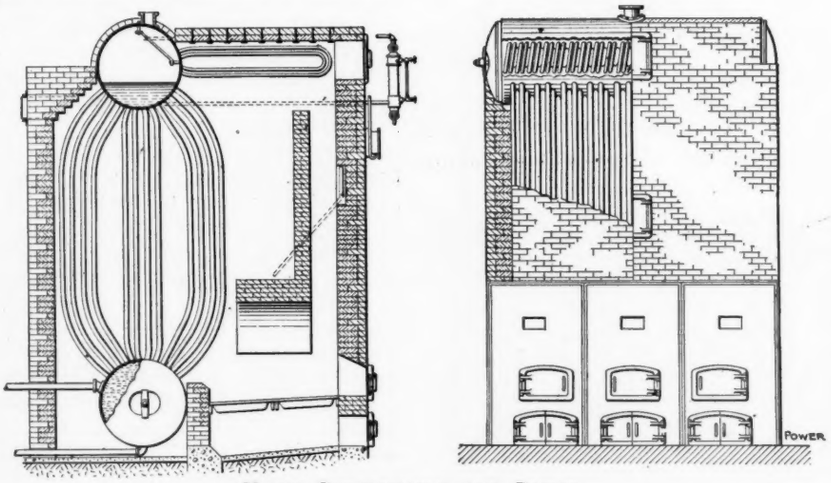
New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Milne Superheater

The Milne superheater, shown in the accompanying illustration, is composed of three simple elements: the dividing wall above the arch, which forms a duct to convey heat upward; the return-bend tubes and the isolated chamber in the upper drum.

The dividing wall is carried upon a heavy I-beam independently of the furnace arch. The superheater tubes are U-shaped. One end enters the upper drum above the water line and the other end enters the isolated chamber in the same drum. This chamber has steam a space suitable to the capacity of the boiler and has a hinged swinging cover closing the chamber, thus a convenient means of access is provided.



MILNE SUPERHEATER AND BOILER

A steam outlet or nozzle on the upper drum connects the chamber and insulation is placed about the steam drum for protection against excess heat.

In starting the boiler the water line is raised about one gage, thus flooding the lower legs of the superheater tubes and providing reliable protection against overheating. When the required pressure is produced steam is drawn off into the mains, thus gradually lowering the water line to the level required to produce the degree of superheat wanted; then the feed valves are opened and the water level and the degree of superheat desired are maintained.

This superheater is very simple, no flooding, draining valves or piping being required, and any degree of superheat within reasonable limits can be obtained. The superheater tubes are made of extra-heavy special tubing to withstand excessive temperatures and at the same time having mass and weight for heat storage in order to maintain uniform temperatures. They combine at the same time suitable areas for free delivery of steam without undue friction or wire drawing. The superheater tubes are expanded, metal to metal in the upper drum, no screwed joints or perishable material of any kind being used.

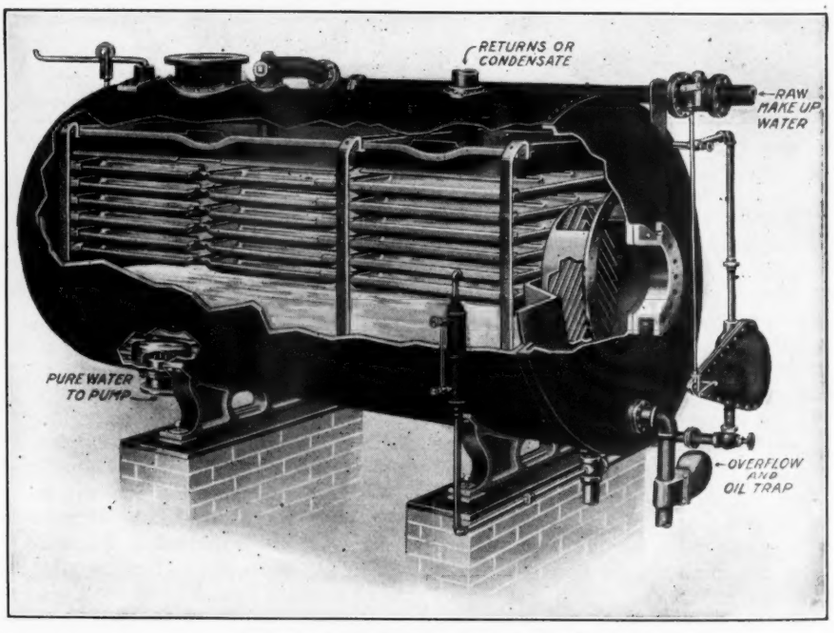
No additional expense for masonry is necessary. Suitable doors are located in the upper part of the setting, which allow access to the superheater tubes for cleaning or repairs. A damper may also be arranged in the duct to regulate the volume of heat that may flow to the superheater tubes or check it entirely, if desired.

A similar form of superheater is used in connection with the Milne multidrum boiler, the design being practically the same except that the duct is not required. The volume of heat allowed to enter the superheater chamber may be regulated by a swinging gridiron damper located above the water tubes connecting the upper drums.

This superheater is manufactured by the Milne Water Tube Boiler Company, 30 Church street, New York City.

Double Service Feed Water Heater

The accompanying illustration shows a sectional view of a feed-water heater designed to keep the make-up water and the condensate separate while passing through the heater. It is manufactured



DOUBLE-SERVICE FEED-WATER HEATER

by the Hoppes Manufacturing Company, Springfield, O.

The heater is known as the "Class H" or water-storage type. All of the parts coming into contact with the feed water are made of cast iron. It is equipped with multitrough-shaped cast-iron pans which, owing to their peculiar design, bring the water on both sides into direct and constant contact with the exhaust steam and furnish a large heating and lime-catching surface.

The heater is also provided with a large oil eliminator, skimmer overflow, automatic regulating valve, and trap and hooded suction. Its distinctive feature is the arrangement for separating the condensate and make-up waters until after flowing over the pans. The returns flow over the rear tier of pans and the make-up water over two or more tiers of pans in the front end of the heater. This brings the collecting pans to the end of the shell next to the removable head and permits these pans to be easily removed for cleaning without disturbing the pans over which the condensate passes. The hot and purified make-up water and the heated returns unite in the storage chamber at the bottom of the heater shell and are pumped thence to the boilers.

Dallett Pneumatic Boiler Scaler

The Dallett pneumatic boiler scale, designed to scale the shell and drums of steam boilers, is, in fact, a pneumatic hammer, striking rapid, light, uniform blows at the rate of about 3000 per minute. Air is admitted through the inlet at the upper end of the tool and the work is produced by the piston striking the chisel which is inserted at the lower end. This tool removes the hardest scale

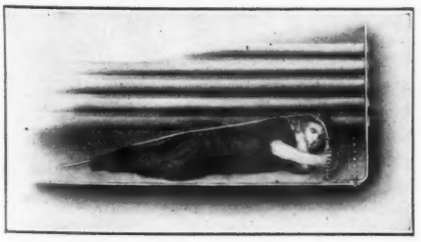


FIG. 1. OPERATOR USING BOILER SCALER

right down to the sheet, but it will not injure the plate. The scale is not cut or chipped off, as the light rapid blows of the piston against the chisel and the vibration caused thereby crack the scale from the shell.

The tool is held against the sheet with one hand. It is very light, weighing only 27 ounces, and the operator could hardly get in a position where its use would be inconvenient. Simple and durable, its operation can be readily understood by referring to Fig. 1.

All wearing surfaces are carefully hardened, and there is but one moving part, the piston.

There is a locking spring at the lower end of the tool for holding the chisel in place while it is being used. The end of the spring snaps into a groove on the chisel shank, thus preventing the

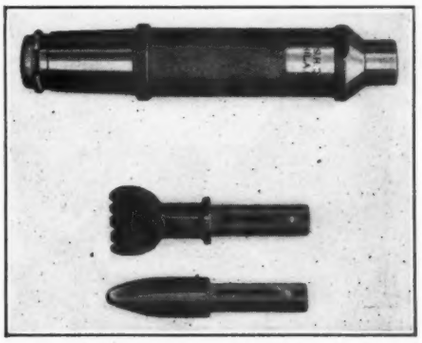


FIG. 2. BOILER SCALER AND SCALING TOOLS

chisel from flying out when the tool is in operation. Its application is not confined to the interior of the boiler, as it can be used for cleaning scale from pipes, condensers, heaters, etc., or wherever there is an accumulation of scale that can be reached with it.

In a plant equipped with an air compressor, the use of this boiler scaler will not necessitate any change in equipment, as the air consumption is but 4 cubic feet per minute. In plants where air is not used, a small air-compressing outfit will be necessary.

With each tool are furnished two chisels which are blunt on the end to prevent cutting or injuring the sheet, but pointed enough to effectively crack the scale; they are shown in Fig. 2.

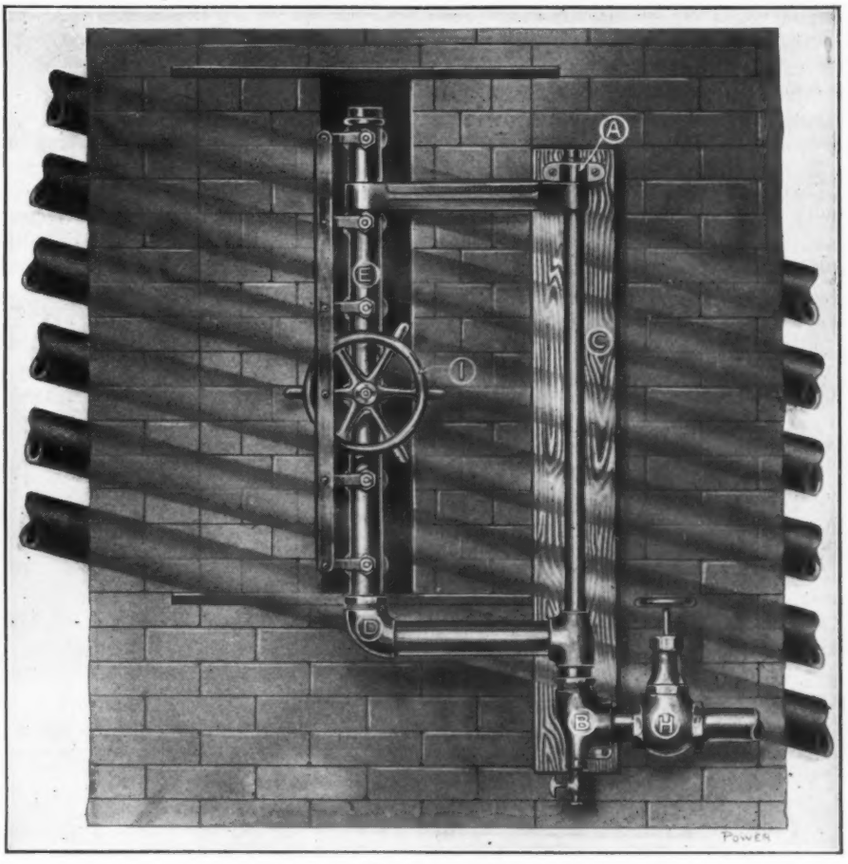
This tool is manufactured by the Thomas H. Dallett Company, Twenty-third and York streets, Philadelphia, Penn.

New Type of "Diamond" Soot Blower

Herewith is illustrated an improved soot-blowing device for use on the various types of horizontal water-tube boilers. It is manufactured by the "Diamond" Power Specialty Company, Detroit, Mich.

A striking feature of this blower is the swivel joint *B*, upon which the nozzle jets are swung in and out of the cleaning holes. This makes it possible to keep the blower, when not in use, entirely on the outside of the boiler, where it is away from all possible injury by the heat.

Its operation is extremely simple, as

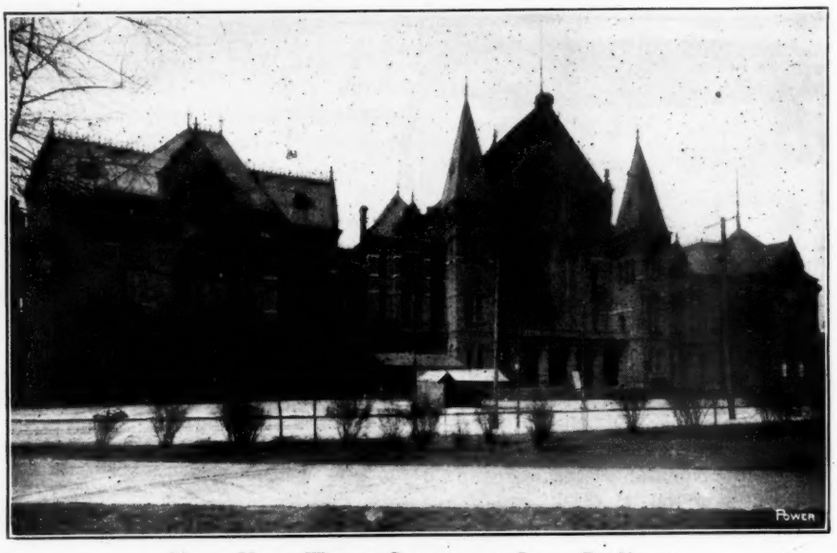


DIAMOND SOOT BLOWER

it consists of merely removing the cleaning door, swinging the nozzles in place, opening the valve and slowly turning the handwheel until it has made one complete revolution.

National Convention of the N. A. S. E.

On September 11 to 16, at Cincinnati, O., will be held the twenty-ninth annual convention of the National Association of Stationary Engineers. The Sinton hotel has been selected as the association's headquarters and the convention will be held at Music hall. The national convention will be held conjointly with the Ohio State convention, which takes place on September. 10, 11 and 12.



MUSIC HALL, WHERE CONVENTION IS TO BE HELD

Arrangements have been completed with the West Shore railroad for a special train to Cincinnati. The train will include a buffet and library smoking car and sleeping, dining and observation cars.

Leaving the Desbrosses station at 2:40 on Sunday afternoon, September 10, the train will stop at various points on its way to Buffalo (arriving in Buffalo at 3:30 a.m.) for the delegates and their friends who desire to board it nearer their homes than New York City, and will arrive in Cincinnati on Monday afternoon, September 11, at one o'clock.

The fare from New York to Cincinnati one way will be $13.50 on the party basis; the Pullman rate will be $4 for a double berth, $7.20 for a section and $14 for a drawing room. The delegates may purchase return tickets at Cincinnati for parties of 10 or more at reduced rates or individual tickets at regular rates, which permit stopovers at Cleveland, Buffalo, Niagara Falls, Rochester, Syracuse, Utica and Albany with a 10-day limit at each of the above cities.

Applications for sleeping-car reservations should be sent to James R. Coe, chairman of the transportation committee, 21 Maiden lane, New York City, as soon as possible. All space will be assigned in the order in which applications are received.

The transportation committee, Messrs. Coe, Paulson, Brainerd, Kaley, Durkin, Penney and Cole, is making every effort to gather a large delegation for the special train and cordially invites all the delegates and their friends to travel by way of the special if possible. The committee assures them all a royal good time.

CONVENTION PROGRAM

At nine o'clock Monday evening the usual reception of the National and State delegates will be held at the Sinton hotel.

The delegates and visitors will meet at the Sinton hotel at nine o'clock on Tuesday morning and march to the convention hall. John A. Kerley, chairman of the local committee, will call the assemblage to order. Governor Harmon will deliver the address of welcome to the State and Mayor Schwab will follow with the city's welcome, National President Carl S. Pearse responding.

Walter Draper, president of the Chamber of Commerce, and Charles H. Wirmel, State labor commissioner, will also speak, responses being made by Edward H. Kearney, national vice-president, and William J. Reynolds, past national president, respectively.

At twelve o'clock the convention will be formally called to order, and at 12:15, E. H. Kearney, national vice-president, will officially open the exhibits. The first session of the convention begins at two o'clock, at which time the Ladies' Auxiliary will convene at the Sinton Hotel hall. The annual meeting of the life and accident department will be held in the hotel hall at seven o'clock p.m., followed by an entertainment in Music hall.

On Wednesday the day will be given over to visits to interesting places of amusement in and around Cincinnati, ball games, bowling, etc..

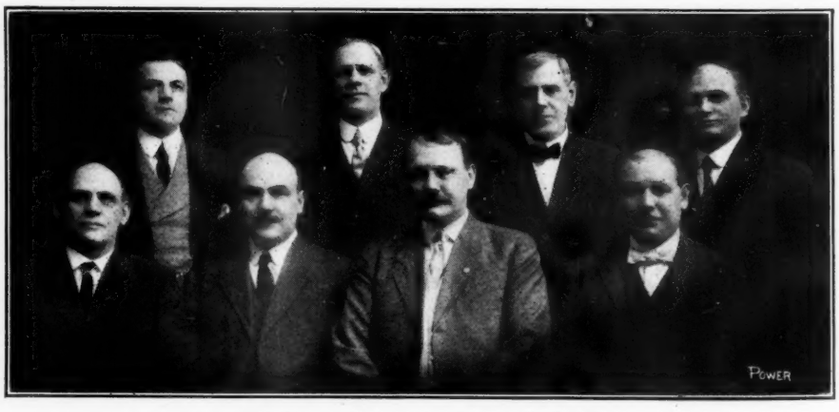
The second session will be held at nine o'clock Thursday morning, followed at ten o'clock by the second session of the Ladies' Auxiliary. Annual memorial services occur at 11:30 a.m. The third session is at two o'clock, and at eight o'clock p.m. an entertainment will be given by the National Exhibitors' Association at Music hall.

At nine o'clock on Friday morning the convention convenes for the fourth session, and will hold its fifth and last session at 2 p.m.

A public installation of officers, followed by a grand ball, will take place at the Sinton in the evening.

The entertainment committee will do all in its power to make the stay of the delegates in this wideawake city pleasurable as well as profitable.

Attention is called to a number of interesting articles in this issue on various power plants operating in the convention city with the hope that they may prove of practical value and incite delegates to find time to personally inspect these plants where possible.



EXECUTIVE COMMITTEE, N. A. S. E.

Standing, left to right: John A. Kerley, chairman; John E. Bruner, vice-chairman; Charles L. Wilson, treasurer; Frank H. Yeager.

Sitting, left to right: Frank Boyer, John T. Schuller; Joseph J. Ahlers, secretary; John M. Wirmel, assistant secretary.

Increased Water Supply for Pittsburg

The city of Pittsburg has recentty awarded contracts for the equipment for the new Aspinwall pumping station which, when completed, will add 100,000,000 gallons per day to the water supply. The new station is to be erected at Aspinwall near the site of the filtration plant, and will eventually contain five 20,000,000-gallon pumping engines but only four of these will be installed at the present time.

At one end of the station will be placed two triple-expansion pumping engines with steam cylinders 32, 60 and 94 inches by 66 inches stroke. The water ends are designed to deliver 20,000,000 gallons of water tvery 24 hours against a head of 275 feet when the steam ends receive steam at 160 pounds pressure and 100 degrees superheat.

The duty guarantees on these engines are the highest ever made, the guarantee calling for a duty of 195,000,000 foot-pounds per 1000 pounds of steam.

At the opposite end of the building two new water ends, similar to those of the units already mentioned, will be placed. The steam ends of these units will be the Holly engines now in the Montrose station which are to be dismantled and reërected on the new water ends. There will remain space in the center of the station for a fifth unit which can be installed when needed.

The new pumping engines will take their supply from a suction line running under the boiler room and parallel to the engines and will discharge into the Montrose rising main which supplies the Troy Hill reservoir. At some future time the water from this station will be delivered to the proposed new Cannage Hill reservoir. The contract for the entire pumping equipment has been awarded to the Allis-Chalmers Company for approximately $300,000.

The Franklin Institute

To promote a correct knowledge of the physical sciences and their proper application in the varied fields of industrial activity, has, since 1824, been the purpose of the Franklin Institute of Pennsylvania. A brief résumé of what it has accomplished since that early date should prove of interest.

In 1824 the Institute held the first exhibition of American manufacturers, and classes in chemistry, mechanics, natural history, architecture, mathematics and drawing were established. There were 304 pupils in attendance in 1826.

During the succeeding years the work was greatly extended and the Institute was asked to conduct experiments and investigations that were of much value to the national Government. Committees were appointed to inquire into the causes of boiler explosions, the efficiency of water as a motive power; systematic meteorological observations were begun, and a system of weights and measures reported on, and investigations were made of the strength of materials, apparatus for testing steam boilers, metals, building materials, etc.

As a result of its recommendations the machine builders throughout the United States adopted a uniform and simplified system of screw threads; and a few years later the United States Government officially adopted the "Franklin Institute Standard," which is now in universal use. The Institute's suggestion that the hundredth anniversary of the United States be commemorated resulted in the holding of the Centennial Exhibition of 1876.

Through its committee on science and the arts during the past 20 years the Institute has investigated over 900 discoveries, processes and inventions in the fields of the physical sciences, geology, mechanical engineering, electrical, civil and sanitary engineering, the textile and leather industries and many other fields.

Its library in Philadelphia is probably the most complete in America for works on scientific and technological subjects and can be freely consulted by anyone interested in manufacturing and industrial activities.

Low Water Causes Explosion

On Monday morning, August 14, a boiler exploded at the mill of the Paragon Paper Company, Eaton, Ind., killing the night fireman and the coal passer. From what can be learned, it seems that the boiler, which was one of a battery of five, was allowed to become entirely empty of water and as the shell became red hot the pressure of the steam from the other boilers with which it was connected ruptured this one.

As the mill was shut down over Sunday and the explosion took place early Monday morning, it is supposed that the steam pressure was being raised preparatory to starting the week's work.

The rupture was along the bottom of the front course and the reaction of the outrushing steam lifted the boiler from its setting and dismantled the one adjoining.

PERSONAL

Gano Dunn, who for some years has been first vice-president, chief engineer and a director of the Crocker-Wheeler Company, has resigned from that company in order to accept an important engineering and executive position. Mr. Dunn will sail shortly for Europe to attend, as president of the American Institute of Electrical Engineers, the meeting during the Turin exposition of the International Electrotechnical Commission, to be held on September 7, 8 and 9, and also the following meeting of the International Electrical Congress.

Prof. O. P. Hood, head of the department of mechanical and electrical engineering at the Michigan College of Mines, has been appointed chief mechanical engineer of the United States Bureau of Mines. Professor Hood will leave some time in September and make his headquarters in Pittsburg. For thirteen years he has been with the Michigan college and during that time has been recognized as an authority on practical mechanical and electrical engineering subjects. As a consulting engineer he has previously served the bureau and has been employed at one time or another by practically every active mine in the copper country. Problems in fuel will be Professor Hood's more immediate work.

SOCIETY NOTES

On September 27 to 30, the semi-annual meeting of the National Association of Cotton Manufacturers will be held at the Equinox house, Manchester, Vt.

Addresses are expected from Hon. James Wilson, Secretary of Agriculture, Prof. Henry C. Emery, chairman of the Tariff Board, Hon. John Wingate Weeks, member of Congress from Massachusetts, and George W. Neville, president of the New York Cotton Exchange. The full program will not be issued until the meeting, but papers of interest to POWER readers are expected on the following subjects: "Alinement of Shafting and Machinery," "Cleaning Machinery by Compressed Air," "Conservation of Water Powers."

On August 10, at the hall of the Beacon Association, National Association of Stationary Engineers, Cambridge, Mass., two of the most prominent members were tendered a reception in recognition of the work each had done for the association. About 150 members of Beacon Association, several national and other officers, and many individual admirers of State President James H. Sumner and Past President Thomas Ray, met upon the occasion and by their presence expressed the high respect in which both officers are held. An excellent program was given, and speeches were delivered by Past National Presidents P. Henry Hogan, Herbert E. Stone, Theodore N. Kelsey; National Vice-president Edward H. Kearney, Massachusetts State Vice-president Thomas J. Maloney; President C. D. Allen, of the New England Association of Commercial Engineers, and Thomas P. Burke, of Providence, R. I. Past National Presidents Kelsey and Stone presented to Messrs. Ray and Sumner respectively, a seal ring and a meerschaum pipe. Mr. Ray was presented with a past president's jewel.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

The pyramids of Egypt form one of the seven wonders of the world.

They were built by the kings as tombs and as everlasting monuments of their own greatness.

Only a few years ago did we begin to learn why they were built and what the numerous carvings and writings meant.

They were boastful stories of the great deeds performed during the life of the king and as such they give us a more or less hazy idea of Egypt as it was thousands of years ago.

The record, however, was very incomplete. It told of the wonders they accomplished and there is still plenty of evidence of the facts.

But the way they did them is still the deepest mystery.

Of the pyramids there are in all about seventy. The size of the Great Pyramid is appalling when we consider the times in which it was built.

Think of this one pile of stone containing 90,000,000 cubic feet of solid masonry! It is 480 feet high and 764 feet square at the base.

It is estimated that it took 360,000 men 20 years to build it.

Some of the stones are so big that we have no machines today powerful enough to move them.

They were handled by machinery of some sort, however, for the marks are still plainly seen after so many centuries.

This Great Pyramid stands exactly on the 13th parallel of latitude, and its four corners point exactly to the four cardinal points of the compass.

But *how* did they do it? How were those enormous stones set in place?

How did they harden copper and brass?

How did they make their wonderful dyes?

There are no records to show. These arts are lost—and lost completely.

The *methods* of Egypt died because there was no way to record them. Printer's ink, the great preserver, was not known. And so, while the accomplishments of Egypt were mighty, they were only *useful* for a limited time and restricted to a limited area and a comparatively few people.

Today, through the medium of engineering papers, modern methods of doing things are being faithfully recorded and *spread broadcast.* They are being *advertised* to a world which makes use of them.

If Egypt, wise and learned, had left records far less perfect than those in just the advertising section of this paper, we would be going on where she left off. We would be using their advanced knowledge.

There are men today who are doing big things in the power plant field. Their deeds are written in improved machinery and recorded in the Selling Section.

In the gradual development of better methods and machines, we sometimes lose sight of the tremendous significance of this progress. Too many lose sight of progress itself and these are they who contemptuously refer to the Selling Section as "mere advertising."

Advertising? Yes, you can gamble it's advertising.

But, by the same token, it's a record of current events of our own history that none of us can afford to overlook.